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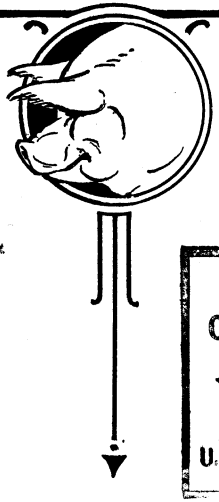
INTERNAL PARASITES OF SWINE



THIS BULLETIN is written in answer to numerous inquiries, largely from swine owners who slaughter hogs on their farms and find evidence of infestation with parasites. From the descriptions and illustrations readers should be able to identify most of the common parasites. In certain parts of the United States hogs are so seriously infested with internal parasites that meat packers make deductions from the prevailing market prices in order to offset the losses that occur from the necessity of eliminating damaged parts.

The hog is generally considered a dirty animal, but actual experience has shown that if given a chance to graze in clean pasture and sleep in a dry, clean place, it will do so and as a result grow faster and make a better profit for its owner.

Swine owners who take special precautions to prevent their young pigs from becoming infested with parasites should reap greater profits from their animals by being able to raise to market age more pigs from each litter. There is also a saving in feed, since healthy animals mature and fatten on less than is needed by parasitized pigs.

The various external parasites and bacterial diseases that affect swine are discussed in other Department publications.

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INTERNAL PARASITES OF SWINE

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CONTENTS

KIND AND LOCATION OF PARASITES OCCURRING IN SWINE

THE INTERNAL PARASITES which occur in swine show a wide variation in structure, size, shape, habits, location, and degree of injuriousness. Some of these parasites are very simple in structure and so minute that they can be seen only with a high-powered microscope. These minute parasites, known as Protozoa, belong to the lowest group of the animal kingdom. The other parasites discussed in this bulletin are worms having a more or less complex structure. When full-grown, worms are visible to the naked eye, although a number of them are very small and would be detected ordinarily only by a specialist. The worm parasites fall into three distinct groups, namely, flukes, tapeworms, and roundworms, each group having a more or less characteristic shape. Roundworms or threadworms are the most important parasites of swine in this country.

Some swine parasites live in various portions of the digestive tract; others occur in the lungs, liver, kidneys, muscles, and various other locations outside of the digestive tract. Wandering young worms penetrate various parts of the body in the course of their migrations. Practically all tissues and cavities of hogs may contain parasites at one time or another.

Only the more important parasites occurring in swine in this country are discussed in this bulletin. The parasites of greatest importance are discussed in greater detail than those of less importance.

GENERAL EFFECTS OF INTERNAL PARASITES

Swine are seriously affected by internal parasites of various kinds, the parasitic infestations of these food animals being second

in importance only to hog cholera. Even comparatively light infestations with the large intestinal roundworm, intestinal threadworms, "thornyheads" or thorn-headed worms, nodular worms, whipworms, kidney worms, and lungworms may reduce pigs to a state in which they are neither well nor definitely sick; in other words, the pigs become unthrifty. Heavy infestations produce emaciation, diarrhea, or constipation and may terminate fatally. The conditions under which pigs are commonly kept in many parts of the United States are highly favorable to the spread of parasitism and its associated evils of unthriftiness, stunting, weakness, emaciation, and a strikingly high mortality among young pigs. A large, if not a major, part of the mortality among young pigs is due to parasitic infestations acquired early in life, perhaps during the first few days.

Parasites not only devitalize pigs by robbing them of essential feed and inflicting injuries to many vital organs, but, in addition, probably render swine more liable to infection with bacteria and other disease-producing agents. The migration of developing worms through various organs and tissues results in more or less serious disability. In mass migrations of worms through the liver, lungs, blood vessels, and in the abdominal and chest cavities, serious consequences are likely to follow and often do. The most serious effects are, as a rule, noted in young pigs.

Young pigs are not only more susceptible to infestation with internal parasites, but also suffer more severely than older pigs from such infestations. Pigs and other young animals of all kinds are special cases and require special care to protect them from an onslaught by parasites and other disease-producing organisms at a period in life when their susceptibility to disease is at its height and when they still lack the hardiness to cope with disease-producing invaders. Due attention to the protection of pigs early in life, and particularly during the first few weeks after they have been farrowed, will save the owner considerable loss resulting from lack of condition, stunting, and deaths, and will more than repay the cost of affording protection from onslaughts by parasites.

The oft-repeated warning that an ounce of prevention is worth a pound of cure finds no better illustration than swine-husbandry operations. Hog growers who are careless with their newly farrowed pigs and make no special provisions for taking care of them, frequently spend relatively large sums of money later for drugs, tonics, and conditioners of all sorts, many of which are practically worthless for alleviating a weakened condition brought about by infestation with internal parasites or for removing parasites. A little well-directed energy spent in protecting pigs from the ravages of parasites is not only cheaper but also far more effective than much of the useless and indiscriminate medication to which many hog producers commonly resort. In addition to actually preventing losses among pigs, control measures against parasites, if carefully and persistently followed, bring about a permanent improvement in swine husbandry by sharply curtailing the sources of infection. These sources are the infested hogs which discharge parasite eggs and the infested pastures and lots on which the eggs and larvae thrive.

CONTROL MEASURES

Prevention in the broad sense covers all efforts that are directed toward avoiding infestation or minimizing its effects. The cardinal principle of prevention is sanitation, or cleanliness. An eminent

FIGURE 1.—Hog lot with corncobs and other litter favorable to the development of parasites. The three pigs shown are of the same age; the two small pigs show the effects of parasites and other hog-lot infections.

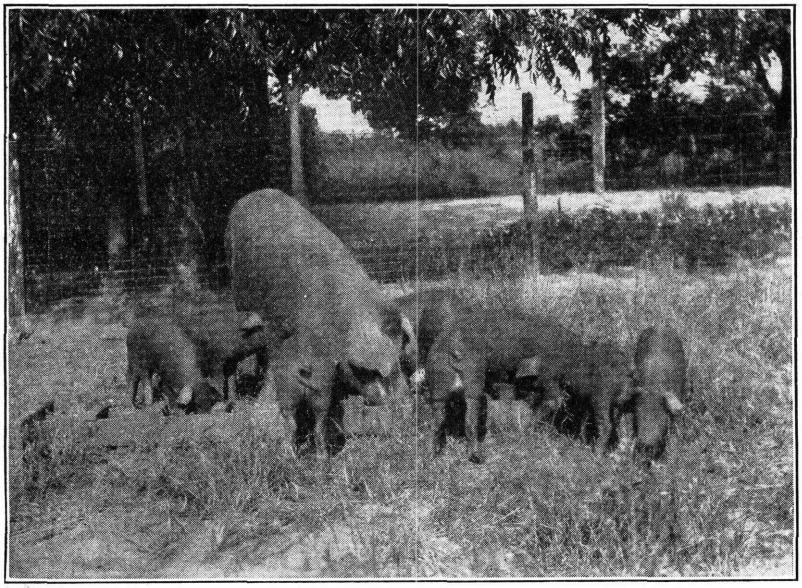

FIGURE 2.—Sow and litter on clean, temporary pasture. Note uniform size of pigs and complete absence of runts. These pigs harbored very few parasites.

parasitologist stated that the way to control parasites in swine is to raise these food animals under less swinelike conditions. This advice is as sound today as it was more than 50 years ago when it was offered. In the minds of many persons the term "swine" is

practically synonymous with "filth", this association being due, no doubt, to the filthy conditions under which swine are kept in some places. Old hog lots with their accumulation of manure and litter, combined with hog wallows, are anything but a pleasing sight (fig. 1). To expect animals raised in insanitary surroundings to develop normally and to produce healthy offspring is unreasonable, and such expectation usually ends in disappointment. For normal growth and development, swine, like all other farm animals, require sanitary surroundings, a balanced and adequate ration, and relative freedom from parasites (fig. 2).

Sanitary surroundings include clean housing, the houses to be of sanitary construction so that the floors and walls can be swept and scrubbed to remove manure, litter, and dirt. The outdoor surroundings should consist of pastures sown to suitable forage crops; the pastures should be well drained and provided with good fences to prevent pigs from getting into low and wet areas. The pastures should be free from litter, since eggs and larvae of parasites thrive under accumulations of all sorts.

Permanent pastures are far less desirable than temporary pastures, but, if permanent pastures must be used, it is essential to rotate stock so as not to keep pigs year after year on the same pastures. Temporary pastures, if well kept, well drained, and sown to suitable forage crops, offer the best and simplest solution to the control of swine parasites. Experience in the Middle West, the South, and other parts of the country has shown that the raising of pigs on temporary pastures causes practically all stunting, diarrhea, general unthriftiness, and such associated conditions as bullnose and mange to disappear. Pigs produced under these conditions are more uniform in size, grow faster, and are almost always more profitable than pigs produced under less favorable conditions. Such well-kept pigs develop at a reasonably rapid rate, are remarkably uniform in size, and under normal market conditions yield a good profit on the investment in breeding stock, feed, and labor. Pigs raised under sanitary conditions are ready for market several weeks earlier than pigs raised without special precautions, and the losses are significantly lower. Those actually occurring are due for the most part to the sows lying on their pigs and other preventable injuries.

In brief, the problem to be solved in connection with parasite control is the protection of pigs from the parasites harbored by sows and older pigs generally. Assuming that it is impracticable for the hog grower to dispose of his infested breeding stock and also that it would be difficult to acquire parasite-free breeding stock, even if he could dispose of the stock on hand, he is faced with the problem of avoiding excessive infestation in his growing pigs. The first essential is to place the pigs on a pasture not contaminated with eggs and larvae of swine parasites. In practice he must supply a temporary pasture; that is, a pasture that has had a crop on it since it was previously occupied by hogs. As an alternative, a permanent pasture that has not had pigs on it for about a year may be substituted. A second important precaution is to keep all hogs, other than the sows, away from the suckling litters and young pigs generally, to prevent contamination of the pastures with parasite eggs and larvae. Finally, the pasture on which pigs are kept must be

well drained and the feeding grounds must be kept free of trash so that the parasite eggs, and larvae which issue from the eggs passed with feces or urine of the sow, will be exposed to the action of the sun, air drying, and other natural factors that are more or less injurious to eggs and larvae of parasites. Such precautions will not prevent parasitic infestation of suckling pigs altogether but will keep the infestations down to a low level. If the pigs are properly fed and housed, protected from association with older hogs other than their mothers, and kept on clean pastures before and after weaning, the light infestations that they will inevitably acquire from the sows will do comparatively little harm.

TREATMENT FOR THE REMOVAL OF PARASITES

Treatment of infested swine for the removal of parasites is an essential part of good management. By removal of the adult parasites, the dissemination of these disease agents through eggs and larvae is checked. In addition, the animal from which parasites are removed is afforded relief from the drain of the parasitic infestation.

Treatment for the removal of parasites involves the administration of drugs which are rather toxic. The aim of medication for the removal of parasites is to kill or otherwise affect the parasites so that they will be expelled from the body. Drugs and chemicals that are injurious to parasites may be temporarily injurious also to the host animals to which these substances are administered. In medication for the removal of parasites the dosage must be adjusted so as to inflict the least injury on the host animal and the maximum injury on the parasites. It is obvious that decisions involving the kind of drug to use, precise dosage, method of administration, the time when treatment should be given for best results, when treatment should be avoided because of the physical condition of the animal, and similar matters require professional knowledge and skill not possessed by most stockmen. Treatment of animals for ailments, including those produced by parasites, is primarily the concern of the veterinarian. A well-trained veterinarian is qualified to make a diagnosis to determine whether treatment is practicable, and if so, to prescribe and administer it. Attempts at medication by stockmen may lead to disastrous results. As will be noted later, there are no established treatments for many of the parasites that infest swine.

Neither is there any known single treatment that is effective in removing several different kinds of worms in infested swine. It is important, therefore, to determine the kinds of parasites present before the feasibility of treatment can be determined or method prescribed. Such determination involves the use of the microscope.

Because most medicaments that are useful for the removal of worms from swine are dangerous if an overdose is administered, treatment must be limited to the individual dosage of the affected animals and be computed accurately on the basis of each animal's weight and general condition. Investigators of the Bureau of Animal Industry have recently used the chemical, phenothiazine, as an anthelmintic which seems to be an exception to the foregoing rule. Methods of administering phenothiazine and the indicated dosages for animals of various sizes are discussed on page 23 of this publication.

The mere fact that worms are passed following treatment is not sufficient evidence that the drug used was effective. A very important consideration is the number of worms that failed to be removed by the drug. The removal, for instance, of a dozen worms from an animal which harbors a hundred or more is not sufficient to warrant the expense of treatment. For this reason the treatments recommended in this bulletin are limited to those that have been tested scientifically and found to be effective in removing all or a large proportion of the worms present.

Treatment is not a substitute for sanitation. Pigs that have been treated should be moved to clean quarters; otherwise the good that has been accomplished by treatment will be nullified by reinfestation. So long as the treated animals are allowed to remain in the lots or pastures where the infestation was acquired they are subject to reinfestation.

PROTOZOA

Protozoa are the simplest forms of animal life, the individual consisting of an exceedingly minute speck of living matter. Although the largest of the free-living Protozoa can be seen by a trained observer with the unaided eye, the parasitic forms of these lowly organisms can be seen only with the aid of a microscope. The small size of the parasitic Protozoa is not an index, however, of their power of doing serious damage. On the contrary, some of the severest diseases that affect human beings, livestock, and poultry are produced by protozoan parasites. Malaria, amoebic dysentery, and African sleeping sickness are among the serious diseases of mankind that are produced by Protozoa. Some important livestock and poultry diseases produced by these organisms are tick fever of cattle, dourine and related diseases of equine stock, coccidiosis of poultry and livestock, and blackhead of chickens and turkeys.

DYSENTERY-PRODUCING PROTOZOA

Swine harbor a number of parasitic Protozoa, including forms that are closely related to, if not identical with, those occurring in human beings. Some parasitic amoebas occurring in the intestine of swine are practically indistinguishable from those known to produce amoebic dysentery in man. Other protozoans of the intestines of swine, known as balantidia, are apparently identical with forms that occur in persons; in human beings these parasites produce a dysentery known as balantidial dysentery.

The dysentery-producing Protozoa are conveyed from infested to susceptible animals by microscopic bodies known as cysts. A cyst is a resistant stage in the life cycle of these parasites. The cysts are discharged with the droppings. Pigs swallow the cysts with contaminated feed or water.

Although it has not been determined to what extent the dysentery-producing Protozoa injure swine, or whether they produce dysentery as a rule, there is some evidence that balantidia are more or less injurious to swine. The possibility of the transmission of these organisms to human beings must be kept in mind. If for no other reason, measures designed to control these parasites in swine are

indicated as a human-health safeguard. The measures to be discussed for the control of coccidiosis are applicable also to the control of dysentery-producing Protozoa.

COCCIDIA

Coccidiosis in swine is due to the presence in the intestine of organisms known as coccidia, *Eimeria debliecki* and related forms. The largest of these parasites in the infective or oöcyst stage are about one five-hundredth of an inch in diameter, and the smallest ones are less than half that size.

Coccidia occur in the cells lining the wall of the intestine, and they undergo their growth and development within these cells. The oöcysts (resistant stages of coccidia) are discharged into the cavity of the intestine and pass out with the droppings. Before they can infect pigs, the oöcysts must undergo development in the open.

Life history.—The oöcysts are swallowed by pigs with feed and water that have become contaminated with the droppings of infested swine. On reaching the intestine, the contents of the oöcyst, consisting of several infective bodies, are liberated, and each infective body is capable of penetrating and damaging a cell of the intestinal lining. Each new infective body develops at the expense of the cell and produces a number of new infective bodies. Each of the newly formed infecting bodies is capable of entering a neighboring cell and repeating the process of development, multiplication, and cell destruction. The multiplication of coccidia does not continue indefinitely however, and if but few oöcysts are swallowed by a pig the few cells that are destroyed by the developing coccidia may not produce serious injury. Sooner or later in the course of the development of coccidia, oöcysts are formed. As already noted, the oöcysts are discharged with the droppings and propagate the infection. Pigs which recover from coccidiosis may continue to discharge oöcysts for a long time. Such pigs are classed as carriers, as they transmit coccidiosis to susceptible pigs.

Damage produced.—In light cases no symptoms are observed. In marked infection pigs are more or less indifferent to their surroundings, show considerable scouring, are generally unthrifty, and become emaciated. Infected pigs may become potbellied and have arched backs. In extreme cases, which may result in death, emaciation is very pronounced, especially in the region of the hips. The bones of the hips become rather prominent because of loss of flesh in that part of the body. These symptoms are associated with a marked destruction of intestinal cells and a swelling and congestion of the intestinal wall.

Treatment.—There is no treatment that is known to be effective in curing coccidiosis in swine.

Control.—The control of coccidiosis is largely a matter of sanitation. Severe cases of coccidiosis are generally noted in pigs that have been raised under poor sanitary conditions, particularly in pigs raised on old hog lots and on permanent low and wet pastures. These conditions afford ideal surroundings for the survival of the oöcysts. Marked improvement has been noted in infested pigs that were moved from their insanitary surroundings to clean pastures or isolated in houses having concrete floors. The removal of an infected

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pig from the area where the infection was acquired reduces the chances of reinfection and affords opportunity for recovery. The recommendations for controlling the large intestinal roundworm should be followed for the control of coccidiosis and the dysentery-producing Protozoa.

FLUKES

Flukes are soft, more or less flattened, leaflike worms that occur in various locations in the animals which they parasitize. These worms have rather complicated life histories; they are transmitted from one host animal to another by way of a snail carrier and in some cases by way of an additional intermediate host or carrier. Although a number of different flukes have been recorded from swine in various parts of the world, only two kinds are considered to be of sufficient importance for consideration in this bulletin.

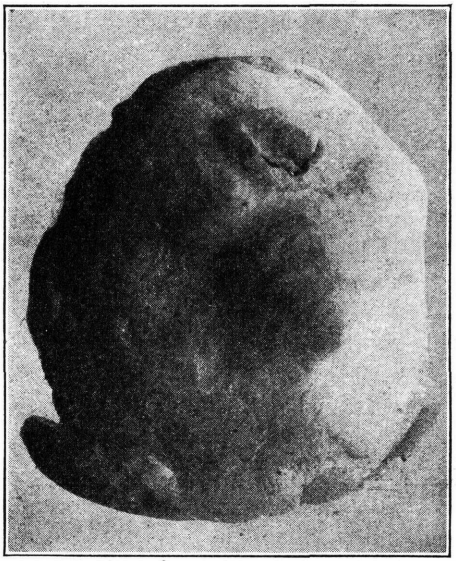

FIGURE 3.—Portion of swine lung showing superficial sacs containing lung flukes.

THE COMMON LIVER FLUKE

The common liver fluke, *Fasciola hepatica*, is primarily a parasite of sheep and cattle, but occurs also in other animals, including swine. The worms are about 1 inch long by about one-half inch wide and are located in the bile duct and bile canals of the liver. Liver flukes in swine are encountered only in areas where these animals are kept on low, swampy ground. Such wet areas are apt to harbor aquatic snails in which the early development of flukes must take place. Sooner or later the young flukes leave the snails. Swine pick up the infestation as a result of swallowing green forage or water harboring the infective stage of the fluke.

Liver fluke infestation in swine is not a serious problem in this country, so far as is known at present. As a precaution against infestation with this parasite, swine should be kept off swampy or boggy pastures, especially in the Pacific Coast and Rocky Mountain

States and in the South, especially along the Gulf coast. In the areas mentioned liver-fluke infestation is a serious problem in cattle and sheep.

THE LUNG FLUKE

Lung flukes, *Paragonimus westermanii*, are thick, oval worms a little less than one-fifth to about three-fifths of an inch long and about one-fifth of an inch or less wide. These parasites are located in sacs or cysts in the substance of the lungs (fig. 3).

Life history.—The eggs produced by the flukes in the lungs are coughed up and swallowed and are discharged with the droppings. In swampy areas the eggs hatch, and the young flukes get into certain aquatic snails in which they develop. They leave the snails and undergo further development in crayfishes. Hogs become infested as a result of eating infested crayfishes. Hogs rooting in wet and boggy pastures have ample opportunity of bringing crayfishes to the surface and devouring them. Once free in the digestive tract of hogs, the young flukes bore their way through the intestinal walls, wander to the lungs, penetrate this vital organ, and develop there to egg-laying maturity.

Damage produced.—No special symptoms have been noted in affected hogs, largely because this infestation has not been studied extensively in these animals. The presence of flukes in the lungs produces an inflammation. When an infested lung is viewed superficially the cysts generally appear as dark areas; if the cysts are located deep in the lungs, the surface of this organ may show only a swelling (fig. 3).

Treatment.—There is no known treatment for the removal of lung flukes from swine.

Control.—The control of lung fluke infestation in swine is based on the mode of transmission. Hogs should be kept off wet and boggy areas. If necessary, such areas should be fenced to prevent swine from having access to them.

TAPEWORMS

Tapeworms occur in domestic animals either as adults in the intestine, as a rule, or as bladder worms located outside of the digestive tract. On casual examination there is little resemblance between a bladder worm and an adult tapeworm. Actually, however, a bladder worm is an incompletely developed tapeworm consisting of a fully formed head and neck. The heads of the bladder worms discussed in this bulletin bear four cup-shaped suckers and a double crown of hooks for the attachment of the future tapeworm to the wall of the intestine of the final host. The head and neck are inverted into the thin-walled bladder at one end, the arrangement resembling the tip of a glove finger that is pushed in at the end. The inverted head and neck appear as an opaque object in the bladder, which is filled with a more or less clear fluid.

If a bladder worm or part of a carcass containing one or more bladder worms is eaten by an animal capable of harboring the adult tapeworm, the head and neck of the bladder worm are turned outward in the stomach, and the wall of the bladder portion of the worm is digested. Upon reaching the intestine, the head becomes attached to the wall by means of its suckers and hooks, and the neck begins

to bud off segments, forming in the course of about 2 months a jointed, flattened, whitish worm which may attain a length of several feet.

Domestic hogs in the United States are not known to harbor adult tapeworms in the intestine. Hogs harbor three species of bladder worms, however, one species developing into an intestinal tapeworm in man and the other two species developing into tapeworms in the intestine of dogs.

THE PORK BLADDER WORM

This tapeworm, *Taenia solium*, occurs in hogs in the immature or bladder worm stage. The fully grown or adult tapeworm occurs in human beings and is known as the pork tapeworm. The bladder worm stage is more or less spherical- to lemon-shaped and is from a little over one-fifth to two-fifths of an inch in maximum diameter (fig. 4).

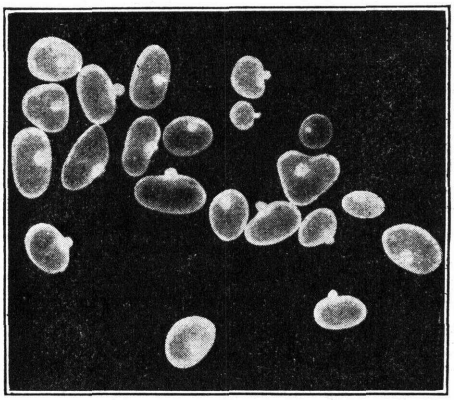

FIGURE 4.—Pork bladder worms removed from the muscles (natural size).

The pork bladder worm occurs in the musculature of hogs, especially in the muscles of the abdomen, the muscular portion of the diaphragm, the loin muscles, the heart (fig. 5), the muscles used in chewing, the tongue, the muscles between the ribs, certain muscles of the hind legs, and shoulder muscles. Pork bladder worms have been found also in the brain, eyes, liver, lungs, pancreas, spleen, and in several other locations.

Life history.—Should a live pork bladder worm be swallowed with raw or incompletely cooked pork by a human being the combined action of the digestive fluid and the warmth of human stomach causes the head and neck of the worm to be pushed out, leaving the more or less shrunken bladder behind the neck; the wall of the bladder is digested. Upon reaching the small intestine, the parasite attaches itself to the intestinal wall by means of its suckers and hooks and develops in the course of about 2 months into a gravid (egg-producing) tapeworm (fig. 6). The tapeworm may attain a length of 3 to 6 feet, the longest joints in the tail end being about half an inch long and one-third of an inch wide. The joints or segments at the tail end become detached from the tapeworm chain and are expelled

with the excreta, new segments taking their place by growth which occurs in the region of the neck.

The detached segments expelled with the excreta contain numerous eggs which become liberated as the segments disintegrate. Pigs become infested as a result of swallowing the tapeworm eggs or entire segments, each containing hundreds of eggs. On getting into the pig's digestive canal, the eggs hatch, and the young worms, which escape from the eggshells, bore into the wall of the digestive canal and are carried by the blood stream, aided probably by their own

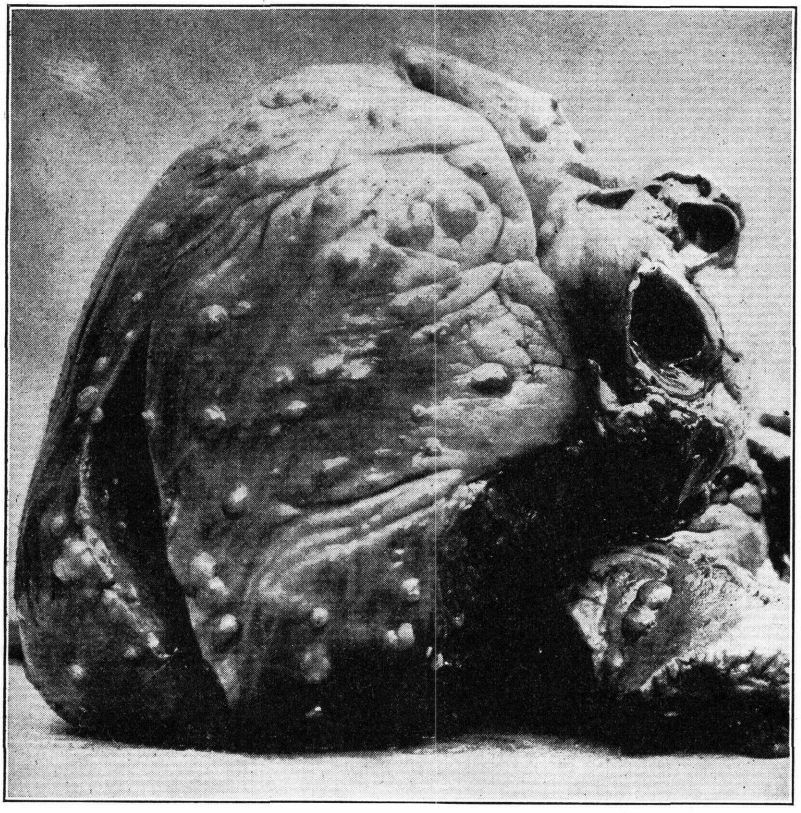

FIGURE 5.—Hog heart showing a heavy infestation with the pork bladder worm.

migrations, to the various locations in which they are known to occur.

Damage produced.—There are no definite symptoms associated with bladder-worm infestation of swine. Infestation is diagnosed, as a rule, after death upon the discovery of the bladder worms in the muscles and other locations already mentioned. Pork infested with these bladder worms is commonly known as measly pork. On account of the danger to human health which might result from the eating of raw or imperfectly cooked measly pork, special precautions are taken to detect these parasites in swine carcasses under Federal meat inspection and competent State or local inspection. Lightly

infested carcasses are passed for human food only after sterilization, following the removal of visible cysts; if the infestation is excessive the carcass is condemned and not used for food.

Treatment.—There is no known practical treatment for the removal of bladder worms from swine.

Prevention.—Infestation can be prevented by a sound system of rural sanitation. Pigs become infested only as a result of swallowing the tapeworm segments or eggs with feed and water that has become contaminated with human excreta or by rooting in contaminated areas. Proper disposal of human excreta will prevent contamination of areas to which swine have access and will prevent infestation. As the tapeworm cysts become rarer in swine, the adult tapeworm also becomes rarer in man, and thus the vicious cycle of the parasite is gradually destroyed.

The pork bladder worm is becoming rather rare in hogs in this country. It is found in swine only in areas where the level of human sanitation is still far below the accepted standards. The pork tapeworm is also capable of developing to the bladder-worm stage in human beings, the bladder worm lodging in the eye and brain as well as in the muscles; when the bladder worms lodge in the human

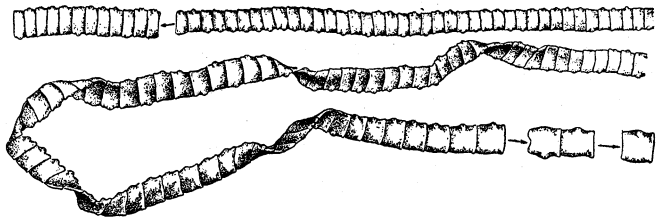

FIGURE 6.—Several portions of a pork tapeworm from the human intestine (nearly one-half natural size).

brain they may produce epilepsy. It is highly important, therefore, to prevent this type of dangerous human infestation by a rigid adherence to sanitary disposal of human excreta on farms and rural communities. Proper sanitation in this respect will remove the danger of infecting human beings as well as swine.

THE THIN-NECKED BLADDER WORM

The thin-necked bladder worm, *Taenia hydatigena*, occurs embedded in the liver, attached to the abdominal organs or free in the abdominal cavity of cattle and sheep as well as swine. It is usually about 1 inch in diameter but may attain a much larger size (fig. 7).

Life history.—The life history is similar to that of the pork tapeworm, except that the dog harbors the adult tapeworm. Dogs become infested as a result of swallowing the live bladder worms. Hogs, in turn, become infested as a result of swallowing the eggs or tapeworm segments eliminated with the droppings of infested dogs which run over hog pastures and lots and leave behind segments and eggs capable of producing an infestation in swine.

Damage produced.—Infestations of swine with the thin-necked bladder worm cannot be diagnosed during life. A light infestation with this tapeworm produces little, if any, injury; heavy infestations are said to be fatal to young animals.

Treatment.—There is no known practical treatment for removing the thin-necked bladder worm from swine or destroying this parasite in the living animals.

Prevention.—The destruction of bladder worms found in swine carcasses, however, is an important method of controlling the spread of this parasite. Under Federal meat inspection and competent State or local inspection, the bladder worms and affected parts are condemned and tanked. When swine are killed on the farm or in country slaughterhouses having no inspection, there is danger that parts affected with bladder worms may be thrown to dogs or, because of improper disposal of offal, may become accessible to dogs. Proper disposal of inedible parts of swine killed on farms, supervision over country slaughterhouses, deep burial, or preferably burning, of swine and other host animals that die on farms, will prevent dogs from becoming infested. Proper attention to dogs to prevent their roaming over pastures and lots, and regular treatment of dogs for the removal of tapeworms,[1] will prevent the spread of this infestation to swine.

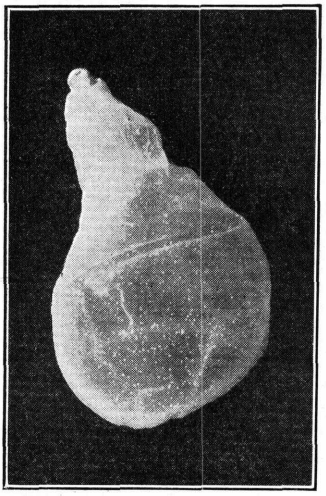

FIGURE 7.—The thin-necked bladder worm (natural size).

THE HYDATID

Hydatids, *Echinococcus granulosus*, are bladder worms located principally in the liver and lungs of swine, but may occur in practically every organ of the body. They vary in size and shape and may attain the size of a child's head. Those occurring in swine livers (fig. 8) range downward from the size of an orange. The bladder is filled with a clear fluid containing minute objects resembling grains of sand. These are the brood capsules which contain multiple heads, each head being capable of giving rise to a tapeworm in the intestine of a dog, cat, or other suitable carnivorous host animal. The primary bladder worm may develop other bladder worms on the inside or the outside, the daughter bladder worms being attached or

[1] For information on treatment of dogs for the removal of tapeworms, see Department Circular 338, Parasites and Parasitic Diseases of Dogs, U. S. Department of Agriculture.

unattached to the mother bladder worm and each daughter bladder worm developing its own brood capsules.

Life history.—The segments containing eggs eliminated by adult tapeworms in the intestine of a dog, or other carnivore, pass out with the droppings and contaminate the soil, feed, and water with which these droppings come in contact (fig. 9). Infested dogs that run over hog lots and pastures may leave tapeworm eggs behind them, each viable egg being capable of producing a hydatid cyst in the liver or some other organ of a susceptible animal by which it may be eaten.

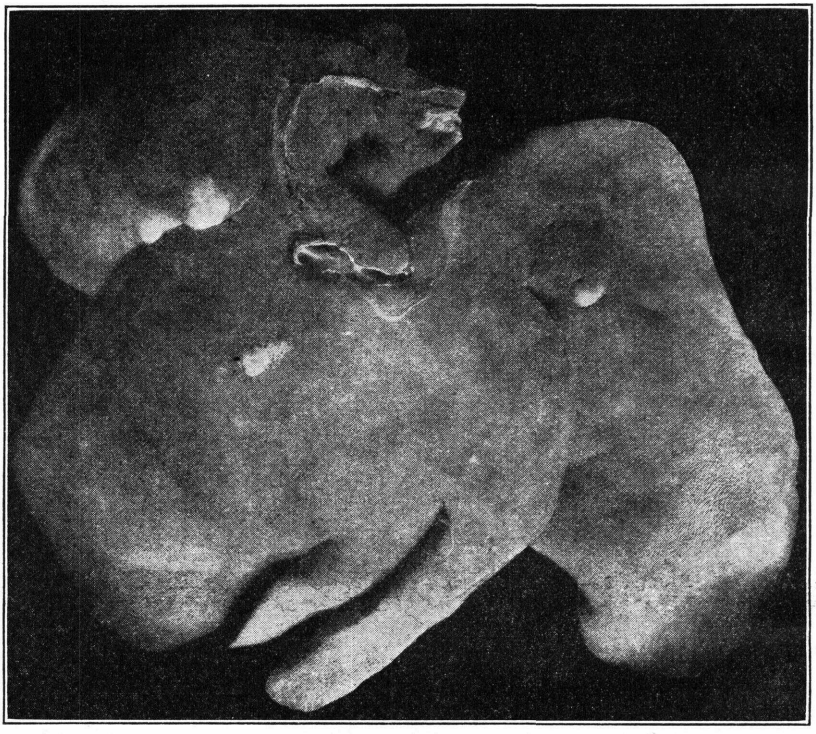

FIGURE 8.—Swine liver showing hydatid lesions (white spots) on the surface.

Hogs acquire hydatids as a result of swallowing feed or water contaminated with the tapeworm eggs or by rooting in contaminated soil. The tapeworm eggs hatch in the digestive tract of swine and reach the liver and other organs through the blood. Presumably the newly hatched larvae in the alimentary canal penetrate its wall and get into the blood stream. The larvae are thus distributed to various organs in which they settle down and develop into hydatids. Dogs, in turn, become infested as a result of eating infested offal from slaughterhouses or the carcasses of dead animals that are left lying in pastures or lots. The tapeworm that develops in the dog is only about one-fifth of an inch long and consists of only three to five segments.

Damage produced.—No distinctive symptoms associated with hydatid infestation of swine have been noted. Considering the size of hydatid cysts and their location in vital organs, these parasites must be classed as decidedly injurious. The sheer weight of the cysts would injure the organs in which they occur and would interfere seriously with the functions of the affected parts.

Prevention.—Prevention should follow the procedures mentioned for controlling the thin-necked bladder worm. The importance of controlling the wandering of dogs over pastures and lots is strongly

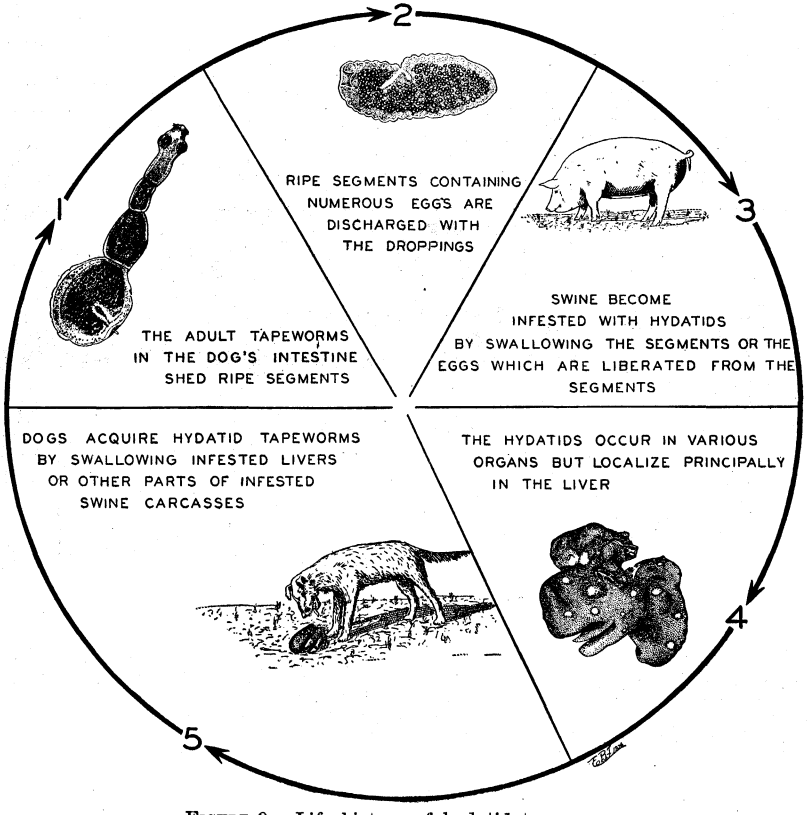

FIGURE 9.—Life history of hydatid tapeworm.

emphasized in connection with hydatids, since these parasites are far more injurious to swine than the thin-necked bladder worms. The need for periodic treatment of dogs to remove tapeworms is another measure essential for controlling hydatids. Not only hogs, but also sheep, cattle, horses, human beings, and other animals are susceptible to hydatids. In human beings hydatids are highly dangerous parasites and an infestation with these worms necessitates a surgical operation of a very serious nature. Preventive measures taken to control hydatids in hogs and other farm animals will aid materially in controlling this serious infestation in human beings.

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ROUNDWORMS

Roundworms are a class of relatively slender, cylindrical worms, more or less attenuated at both ends. Roundworms occurring in swine show a wide range of size, the smallest mature worms being about one-sixth of an inch long and as thin as the finest silk thread, whereas the largest ones are 10 or more inches long and as thick or thicker than an ordinary lead pencil. Roundworms occur in a variety of locations inside and outside of the digestive tract, some of them wandering in the larval or adult stage to various locations in which they become trapped in one way or another. Some of the roundworms, such as the stomach worm, are named for the location in which they are principally found.

The roundworms discussed in this bulletin, with the exception of trichinae, reproduce by means of eggs expelled by the worms. The eggs, which can be seen only with the aid of a microscope, are passed with the droppings (urine in the case of kidney-worm eggs)

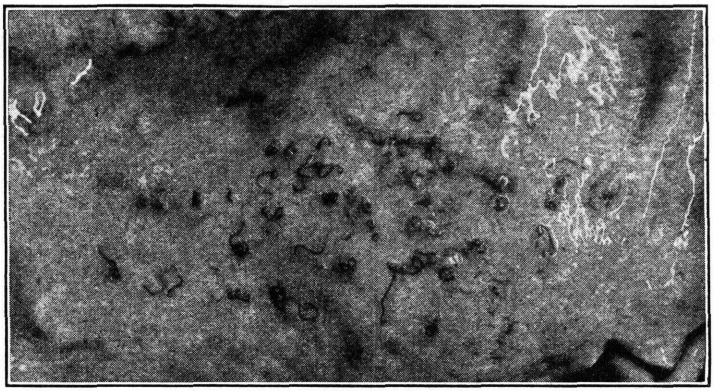

FIGURE 10.—Portion of inner surface of a hog's stomach showing thick stomach worms (natural size).

of infested swine. The eggs of certain roundworms hatch on the ground, and the newly emerged worms or larvae must undergo their early development on soil or on pastures before they can infest swine; the free-living stages are too small to be seen with the naked eye. The eggs of other species develop to the infective stage without hatching, while those of still other species develop to the infective larval stage only if they are swallowed by an intermediate host, usually an insect. In the latter case, hogs become infested as a result of swallowing the infested intermediate host.

STOMACH WORMS

Swine harbor three species of stomach worms. The red stomach worm, *Hyostrongylus rubidus*, is a small, delicate, reddish, threadlike worm, normally about one-fifth to one-third of an inch long and one two-hundred-and-fiftieth of an inch thick. These worms are transmitted from infested hogs to young pigs through larvae which hatch, on pastures and on lots, from eggs deposited by the worms in the stomach. The eggs are eliminated with the droppings of swine,

hatch on pastures and on bare soil, and develop to the infective stage in a few days, under favorable conditions. Hogs become infested with red stomach worms by swallowing feed or water contaminated with the infective larvae.

The thick stomach worm of swine (fig. 10) may be either of two species, *Ascarops strongylina* or *Physocephalus sexalatus*. These worms are more or less similar in appearance, whitish or reddish in color, between a fifth of an inch and an inch long, and about an eightieth of an inch thick. The thick stomach worms of hogs are transmitted by various species of dung beetles which feed and breed in swine manure. The beetles swallow the worm eggs with the manure of infested swine and transmit the parasites when swine eat the infested beetles.

Damage produced.—Stomach worms contribute generally to the emaciation and digestive disturbances so characteristic of infestation with parasites. The presence of these worms in the stomach is usually associated with a catarrhal condition of the stomach wall. The presence of thick stomach worms, in particular, is usually associated with a thick, mucuslike, false membrane on the stomach wall, the worms being located between this false membrane and the stomach wall proper. Young worms may penetrate the stomach wall. These conditions interfere, no doubt, with the process of digestion.

Treatment.—Carbon disulphide administered at the rate of 2 to 2½ fluid drams (8 to 10 cubic centimeters) per 100 pounds of live weight is effective in removing the red stomach worm from swine and has also been recommended for the removal of the thick stomach worm. The drug may be administered in capsules or by stomach tube. Food should be withheld for 36 to 48 hours before treatment, as the presence of food in the stomach interferes with the action of the drug and tends to reduce the value of the treatment.

Control.—The swine sanitation system, including the modification for kidney-worm control (pp. 38–39), will help to control the red stomach worm. Sanitation in general, with emphasis on the avoidance of old hog lots, straw piles, and permanent pastures in which locations dung beetles are most prevalent should prove helpful in controlling these pests.

THE INTESTINAL THREADWORM

Intestinal threadworms, *Strongyloides ransomi*, are especially common in pigs during the suckling stage and persist, usually in smaller numbers, for a long time after weaning. The adult parasites, all of which are females, live in the small intestine. These worms are very fine, delicate, whitish creatures, about one-sixth of an inch or less long and about one-thirtieth of an inch wide.

Life history.—The eggs produced by the worms in the intestine are eliminated with the droppings. On bare soil or on pastures, the eggs hatch within a few hours under favorable conditions, and the larvae which issue from the eggshells follow one of two courses of development. Some larvae develop directly to a stage that is infective to swine, whereas other larvae develop on the ground into male and female worms. These worms mate, and the females produce eggs which hatch on the ground; the young worms issuing from these eggs develop to a stage that is infective to swine. In either case, the net

result is the development of young worms capable of entering the bodies of pigs.

Infection results from the pigs eating feed contaminated with the infective larvae. Pigs can also become infected as a result of the penetration of the larvae through the skin, as described for the kidney worm (p. 34).

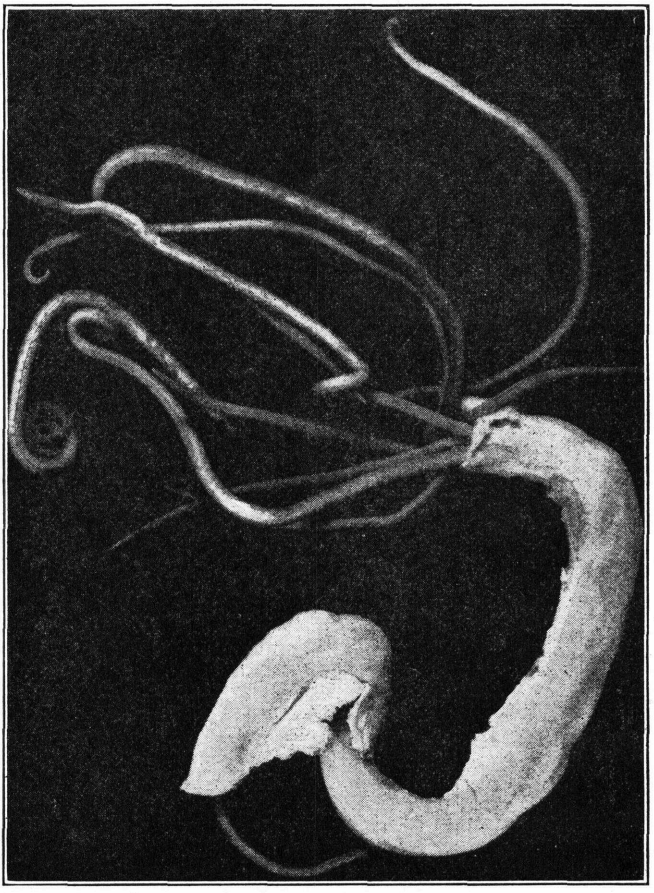

FIGURE 11.—Portion of small intestine of a pig infested with ascarids. Some of the worms are protruding from, and a few are completely outside of, the intestine (one-half natural size).

Damage produced.—Young pigs appear to be more heavily infested with these parasites than are grown hogs. Young pigs harboring massive infestations of threadworms suffer from diarrhea and loss of appetite, fail to grow normally, and may die. Threadworm larvae wander extensively in the bodies of hogs, causing severe damage to muscles and vital organs. Pigs, and sows in a weakened condition from suckling their litters, may die as a result of invasion by the larvae of the heart, brain, spinal cord, and other organs.

Treatment.—No treatment based on thorough tests has yet been devised for the removal of intestinal threadworms from swine.

Prevention.—Keep sows with pigs in clean quarters with clean bedding. Avoid permanent hog lots and pastures.

THE LARGE INTESTINAL ROUNDWORM OR ASCARID

The large intestinal round worm, *Ascaris suis*, is a large, thick, yellow or pink worm, about the size of an ordinary lead pencil (fig. 11). The normal location of the adult parasites is the small intes-

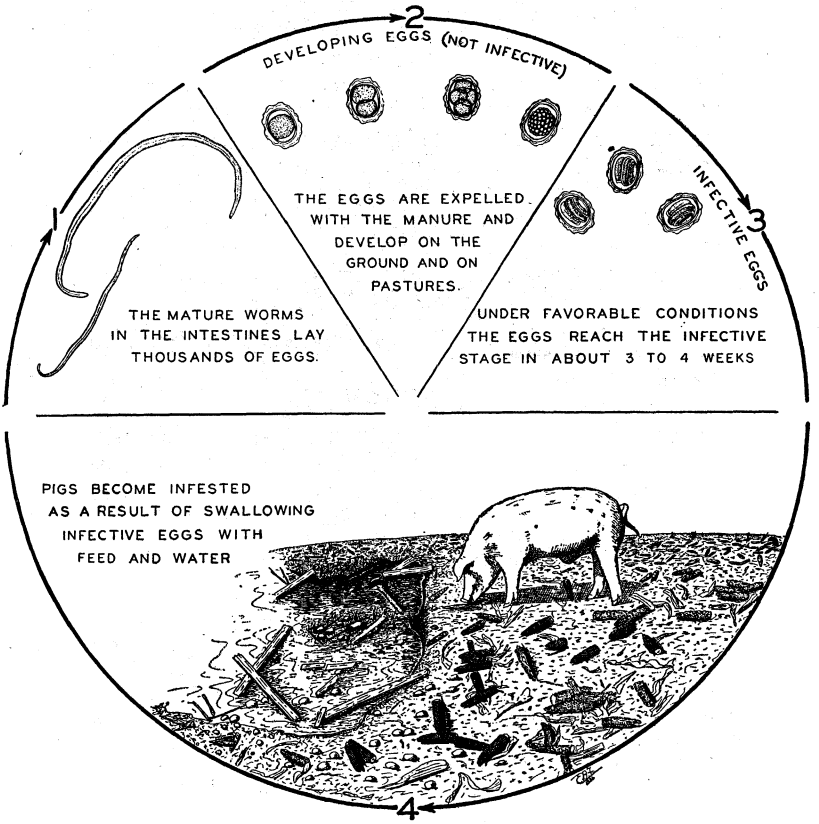

FIGURE 12.—Life history of swine ascarid.

tine; wandering adults may occur also in the stomach, in the lower portion of the alimentary canal, in the bile ducts of the liver, in the gall bladder and in other parts of the body which have channels of communication with the gut. The young migrating worms occur in the blood stream, the liver, lungs, and other organs and tissues.

Life history.—The adult females produce thousands of eggs daily (fig. 12). It has been estimated that a single full-grown female worm in the intestine of a hog may contain between twenty-six and twenty-seven million eggs. The eggs are eliminated from the hog's intestine with the droppings and are not infective until they have

undergone development in the open. Under favorable conditions of temperature and moisture, the eggs reach the infective stage in about 3 to 4 weeks; under unfavorable conditions, such as low temperatures and lack of moisture, the development of the eggs may be prolonged to several months. When the eggs have attained the infective stage, a tiny worm already undergoing a molt is contained in the eggshell.

Pigs become infested with ascarids by swallowing the infective eggs with feed or water. Ascarid eggs are abundant on hog lots, pastures, and other locations contaminated with the droppings of infested hogs. The young worms present in the eggshells become free in the pigs' intestines. These microscopic worms penetrate the wall of the intestine and travel in the blood stream to the liver, and from the liver to the lungs; in the lungs the worms leave the small

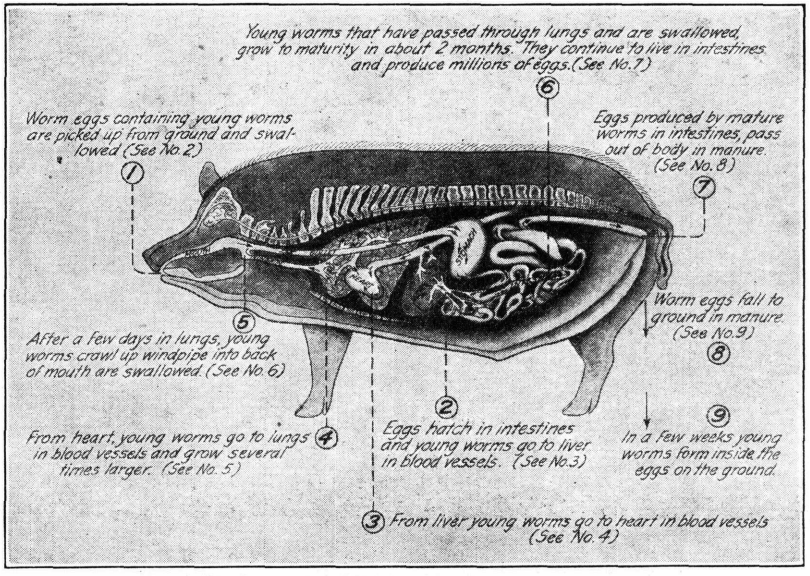

FIGURE 13.—The roundworm's journey through the pig.

blood vessels and get into the air spaces. From the air spaces in the lungs the worms travel upward along the branches of the windpipe, in the windpipe proper, reach the back of the mouth, and are swallowed. On getting back into the intestine, they settle down and grow to egg-laying maturity in about 2 to 2½ months. The roundworm's journey through the pig is shown in figure 13. If many young worms make this curious roundabout journey at the same time, the resulting injury to the lungs is likely to be very serious and may prove fatal in the case of very young pigs.

Damage produced.—Ascarids in the intestine may produce digestive disturbances and a capricious appetite, retard growth and development, and interfere with the well-being of pigs in other ways (fig. 14). In exceptional cases, particularly when pigs are on an inadequate diet, infested animals may become anemic, suffer from colic, and, in extreme cases, they may suffer from convulsions. Dur-

ing the migration of numerous young ascarids through the lungs, pigs have difficulty in breathing and may die of pneumonia. Probably many, if not most, cases of thumps in young pigs are caused by ascarid migrations through the lungs, but other causes of thumping must not be overlooked. Pigs that survive a severe infestation of the

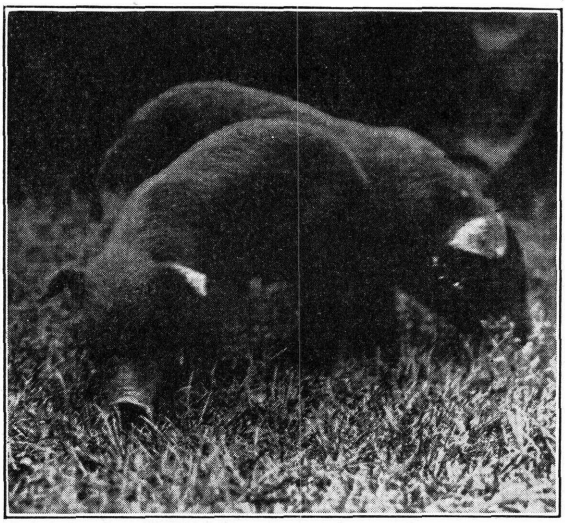

FIGURE 14.—Pigs showing the effects of roundworm invasion of the lungs 8 days after infection.

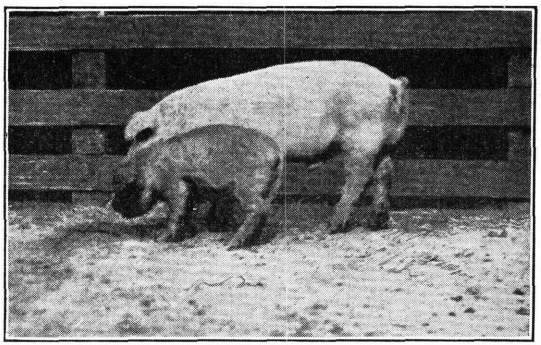

FIGURE 15.—Two pigs of the same age. The large one is normal; the small one was stunted by roundworms and other hog-lot infections.

lungs with ascarid larvae may not recover fully and often fail to grow and develop at a normal rate (fig. 15). Pigs are far more susceptible to ascarids than grown hogs, and very young pigs suffer seriously from the effects of these parasites.

Although the damage to the liver and lungs done by the migrating larvae heals as a rule, the liver is sometimes permanently affected by the massive migration of young worms. The repair to the damage results in numerous scars, the entire surface of the liver becom-

ing peppered with whitish areas (fig. 16). In some lots of hogs as many as 35 percent of the livers have been thus affected.

Treatment.—A generally satisfactory treatment for the removal of ascarids from the intestines of swine consists in the administration with a dose syringe or by means of a stomach tube of wormseed oil (oil of chenopodium) at the rate of one-half to 1 fluid dram (2 to 4 cubic centimeters) to a 100-pound animal, immediately preceded or followed by at least 2 fluid ounces (60 cubic centimeters) of castor oil, or the drug may be administered in the oil. Some veterinarians substitute calomel or aloes for castor oil; others use Glauber's salt or Epsom salt in solution on oats or in slops at the rate of 1 pound of salt to 10 hogs, 3 hours after treatment. Al-

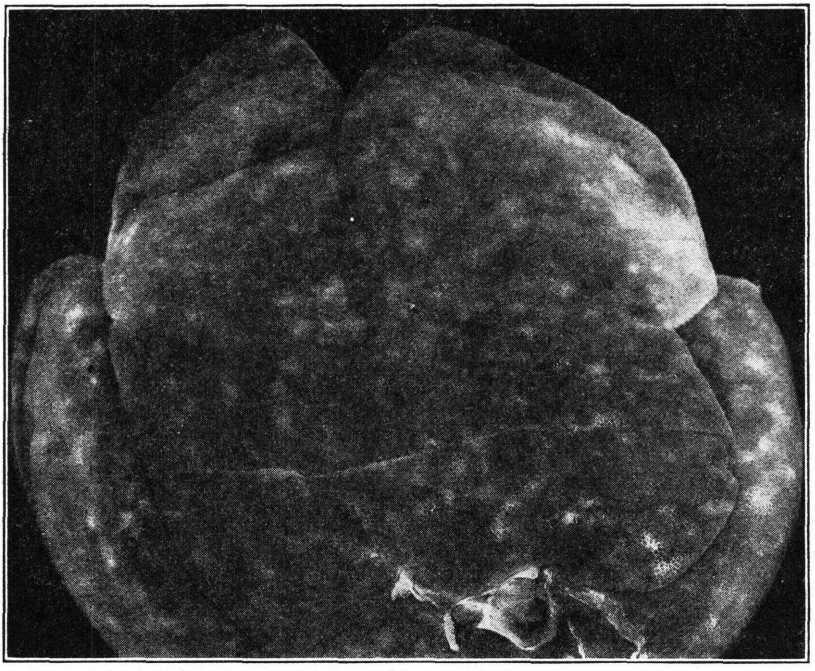

FIGURE 16.—Swine liver showing numerous small scars (whitish areas) produced by migrating ascarid larvae.

though doses for animals of various sizes are usually computed on the basis of weight, it is likely that a dose of 2 fluid drams of oil of chenopodium is adequate for hogs weighing 300 to 400 pounds. Swine should be fasted for 18 to 24 hours prior to treatment and should not be fed or watered until 3 hours after treatment. Oil of chenopodium should not be administered to animals suffering from fever, constipation, intestinal catarrh, or necrotic enteritis, and the treatment should not be given to young pigs or to pregnant sows.

Santonin, formerly recommended for the removal of roundworms, is not very effective in the doses recommended and its cost is prohibitive.

Although the newer drug, phenothiazine, is not more effective than wormseed oil for the control of ascarids, it has certain

advantages as a treatment for the removal of nodular worms. Satisfactory results may be obtained with a dose rate of 1 gram of phenothiazine for each 5 pounds of live weight for pigs weighing up to 50 pounds; 1 additional gram should be given for each additional 10 pounds of body weight, with a maximum dose of 30 grams. The drug may be administered in the feed if the pigs are in a pen that is familiar to them and if sufficient space is provided at the trough for all animals. They should be reasonably uniform in size and sufficiently hungry to consume all the medicated feed in a short time. The drug should be mixed with from three to four times its weight of dry ground feed. If the pigs are accustomed to feeding on slops the medicated mixture may be made into a thick mass, but not into a thin slop. In some cases phenothiazine produces paralysis and other toxic symptoms, especially in very young animals.

Phenothiazine may be administered to swine in capsules if the operator is sufficiently skilled to avoid lodging the capsules in the pharyngeal pouches.

If practical, pigs should be confined for a few days after anthelmintic treatment in a pen not intended for their permanent use. Treatment may be repeated in 10 to 14 days, if necessary, to remove any worms not affected by the first treatment.

Control.—Control of ascarid infestation in swine can be accomplished successfully by following the sanitation system of swine management. This system was developed by the Federal Bureau of Animal Industry as a result of scientific investigations carried out in cooperation with farmers in the Middle West, in the South, and elsewhere in the United States. The swine-sanitation system, outlined below, is the basis on which control measures for all swine parasites should be undertaken, the system as a whole requiring certain modifications here and there, in order to adapt it to the control of parasites other than ascarids. Modifications already worked out in detail for kidney worms are discussed elsewhere in this bulletin. The basic sanitation principles, as worked out for ascarids, will control effectively or to some extent practically all the important swine parasites. Briefly the system is as follows.

SWINE-SANITATION SYSTEM

Before farrowing time the farrowing pens, which should be of sanitary construction, should be thoroughly cleaned (fig. 17) by removing all manure and other litter and scrubbing the floors, walls, troughs, and guard rails with hot water and lye. The water should be very hot and should be used liberally in order to destroy the worm eggs; the lye helps to remove dirt. If the farrowing pens are not artificially heated, the cleaning should be done in the fall before freezing weather, and should be kept closed until used by sows and pigs.

The sows should be placed in the clean pens a few days before farrowing but not until the mud and dirt on their skins have been removed by careful washing with soap and warm water. The udders particularly should be well washed, and no part of the sows' bodies, including the feet, should be overlooked in the cleansing process. The mud and filth adhering to the sows' bodies, udders, and feet are likely to contain numerous worm eggs and disease germs, so

that the newborn pigs are likely to swallow infective material with the first few mouthfuls of milk.

After farrowing, the sows and pigs should not be allowed out of the farrowing pens until they are hauled to a pasture which has been prepared especially for them. They may be moved to the

FIGURE 17.—Cleaning the farrowing pen. The equipment consists of a shovel, a broom or brush, and plenty of hot water, soap, and lye.

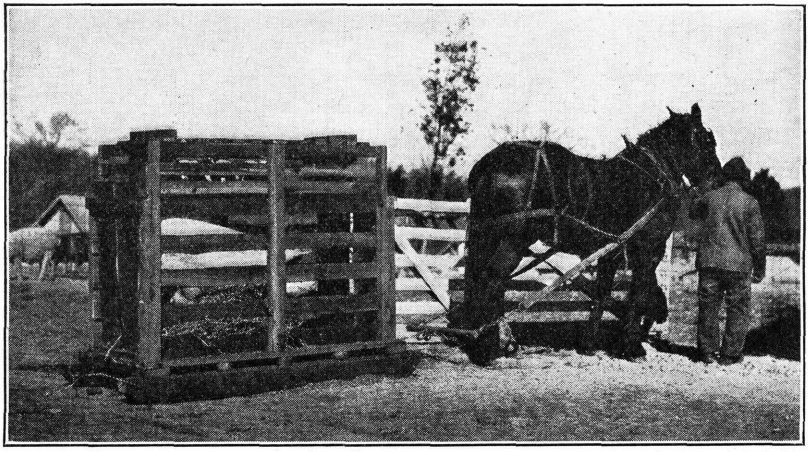

FIGURE 18.—A double-decked crate for hauling the sow and pigs from the farrowing pen to the pasture. The sow is placed below, and the pigs are above.

pasture, in from a few days to 2 weeks, in a double crate on a sled (fig. 18) which can be backed up to the door of the pen for loading. The lower compartment of the crate is for the sow, the upper is for the pigs. A very essential feature of the system is the avoidance of old hog lots and permanent pastures. Hence the pasture to which

the sows and pigs are moved should be one that has been under cultivation and has been sown to a suitable forage crop, preferably a leguminous crop. The pasture should be provided with individual shelter houses for the sows and their litters. A safe, clean water supply should be provided. No other hogs should have access to this pasture, nor should the pigs be allowed to run back from the pasture to the barnyard or hogyard or to any other place contaminated with the manure of other hogs. Failure to follow this precaution has virtually nullified the benefits of the entire system in many instances. When it becomes necessary to move the pigs after weaning to another pasture, the same precautions should be followed with regard to arrangements for a clean temporary pasture. This pasture should not have been occupied by hogs previously, and should have good shelter houses and a safe water supply. The safe procedure is to keep the pigs on clean pastures, under conditions which will bar access to dirty hog lots, until they are ready for market.

The swine sanitation system just outlined was originally developed for spring pigs farrowed in the Northern or Central States. In

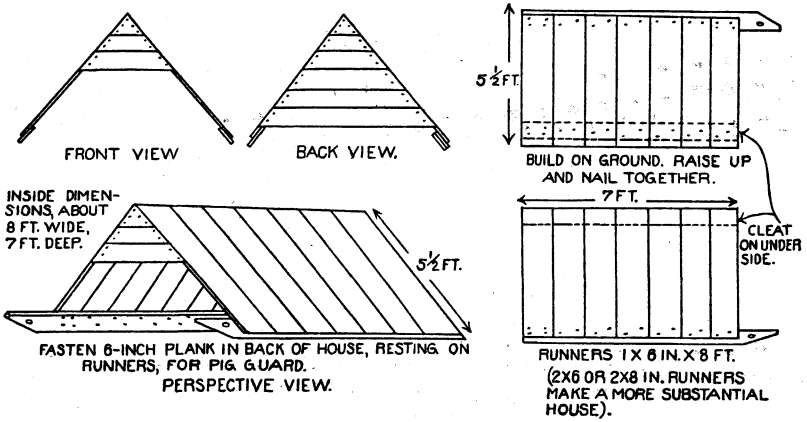

FIGURE 19.—Individual portable farrowing house suitable for use in the South.

the case of fall pigs farrowed in such States, the arrangements may be modified as follows:

The permanent farrowing house need not be used. If the sows have been running on pasture and are not incrusted with mud and filth, they may be transferred directly, without washing, to the special pasture, and allowed to farrow in the individual houses on the pasture. This modification is applicable to the South for both spring and fall farrowing and is commonly followed in many of the Southern States. In the South simple, inexpensive **A**-type houses are provided on the pasture for the sow and her litter (fig. 19).

By following the swine sanitation system the hog grower can reduce considerably the cost of producing his pig crop. With due attention to all the steps in the system, the number of sows required to produce a given pig crop can be reduced by as much as 33 percent, thus effecting a considerable saving in the cost of production. Moreover, pigs raised under the sanitation system are noticeably uniform

in size (fig. 20), runtiness being greatly reduced, and the time required for raising the animals to market size can be shortened by from 4 to 8 weeks. This effects a saving in feed and care and reduces the risk of loss from infectious diseases because of the shorter holding period.[2]

It is important to remember that hog-cholera control by approved methods should be practiced along with sanitation.

The ascarid that occurs in human beings is closely related to, if not identical with, the pig roundworm. In persons this parasite

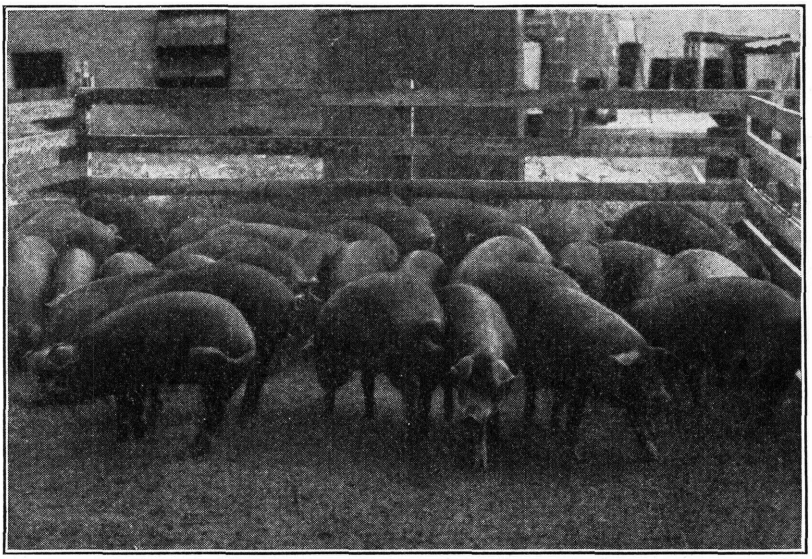

FIGURE 20.—Pigs raised under the sanitation system; note uniformity in size and quality. These pigs averaged 220 pounds when they were 6½ months old.

undergoes migrations similar to those in the pig. While it has not yet been established conclusively that the pig roundworm will develop in the human intestine, it has been shown definitely that the larvae of the pig roundworm will migrate to the lungs of human beings and produce serious damage. Children, in particular, are likely to "pick up" ascarid eggs while playing in areas to which pigs have access, especially through putting soiled fingers in the mouth or eating fruit that may have fallen on the ground. A strict adherence to the sanitation system of swine husbandry involves the keeping of pigs on well-fenced pastures. This precaution is a human health safeguard as well as a sound animal-husbandry practice.

THE THORN-HEADED WORM

Thorn-headed worms, *Macracanthorhynchus hirudinaceus*, are milk white to bluish in color and cylindrical in shape, the largest being about the size of a lead pencil. The head is provided with a spiny proboscis (snout) by means of which the worm becomes firmly

[2] For additional information on controlling roundworms see U. S. Department of Agriculture Leaflet No. 5, The Prevention of Roundworms in Pigs.

attached to the wall of the gut (fig. 21). The attachment of the worm is so firm that it requires some effort to detach one from its hold.

Life history.—The adult female worms produce numerous eggs which pass out with the manure (fig. 22). White grubs, which are the larvae of May beetles, or June bugs, eat the eggs along with swine manure or with soil contaminated with the manure of infested swine. The eggs hatch in the bodies of the grubs and develop to a stage that is infective to swine. Pigs obtain and swallow the grubs by rooting in soil in which they occur. The young worms escape from

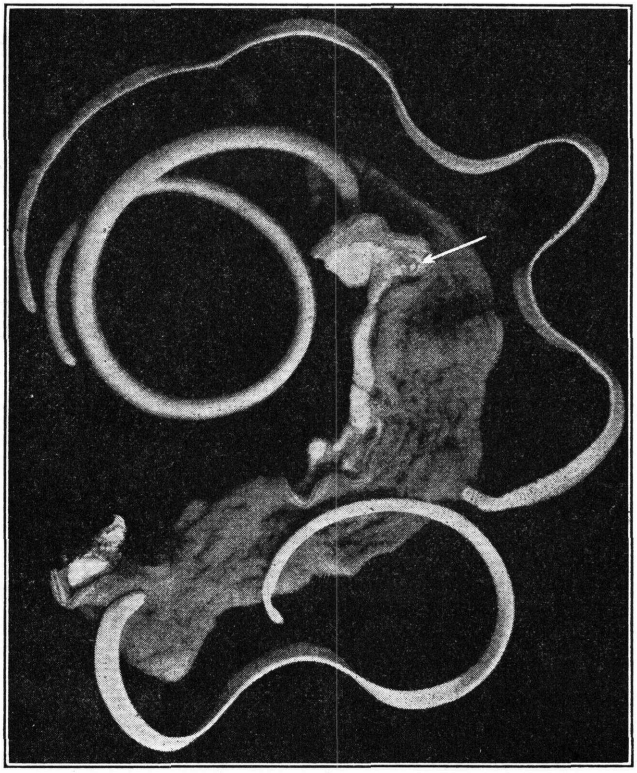

FIGURE 21.—A small portion of a hog's intestine showing thorn-headed worms attached. The arrow indicates a swelling in the outer intestinal wall produced by the worm (one-half natural size).

the bodies of the grubs as a result of the process of digestion in the pig's stomach or intestine or both, settle down in the intestine, and develop there to egg-laying maturity in about 8 weeks.

Damage produced.—No special symptoms have been attributed to infestation with thorn-headed worms, although these parasites are decidedly injurious. At the place of attachment to the intestinal wall a swelling or nodule appears (fig. 21); this is visible on the outer coat of the intestinal wall. Sometimes the injury is so deep that the intestine is perforated, which causes peritonitis, an inflammation of the delicate lining of the abdominal cavity. This condition is

fraught with serious and often fatal consequences. These worms contribute also their share to the general unthriftiness that is nearly always associated with parasitic infestation and, in exceptional cases, may produce the serious condition already noted.

Treatment.—Various drugs known to be effective in removing certain parasites from swine and other domesticated animals have proved rather ineffective in removing thorn-headed worms. In the absence of effective medicinal treatment, control measures constitute the only hope at present of keeping swine free from thorn-headed worm infestation.

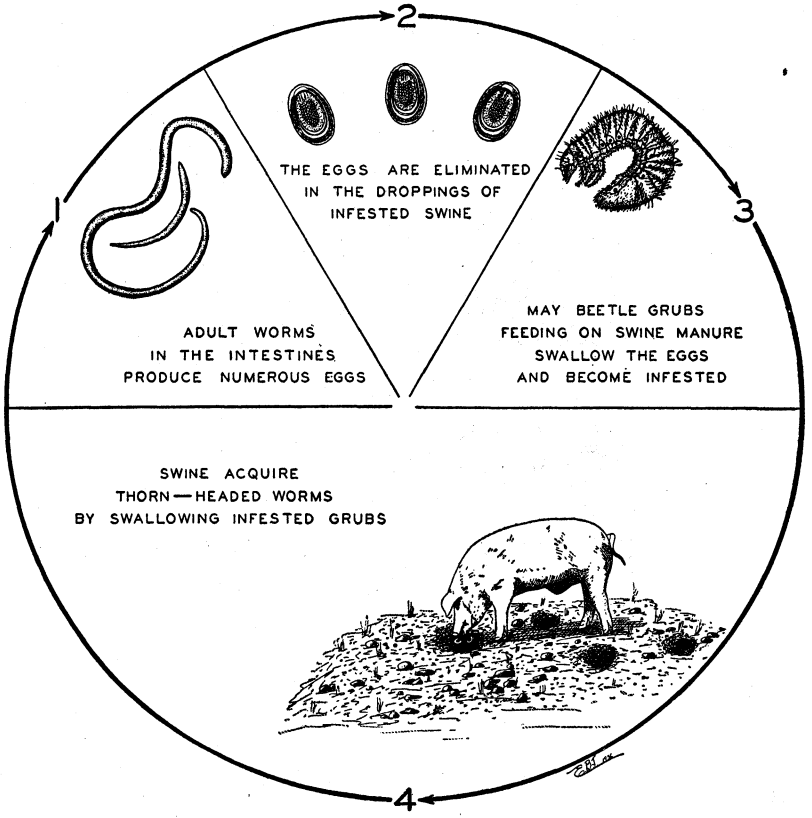

FIGURE 22.—Life history of the thorn-headed worm.

Control.—Ringing the noses of swine tends to keep them from rooting, and diminishes the danger of the pigs swallowing infested grubs. Sanitation, especially the avoidance of old hog lots, straw piles, and permanent pastures, is an additional safeguard.

NODULAR WORMS

Three species of nodular worms are of common occurrence in swine in this country. The common nodular worm of swine, *Oesophagostomum dentatum*, is found in practically all parts of this country, whereas the long-tailed nodular worm, *O. longicaudum*,

and the short-tailed nodular worm, *O. brevicaudum*, are more or less limited to the South. Adult nodular worms in the lumen (cavity) of the cecum and colon are slender, whitish, or grayish-brown worms, from about one-third to slightly over one-half an inch long by about one-hundredth of an inch wide (fig. 23). The immature stages of these parasites occur in the walls of the cecum and colon where they undergo their early development.

Life history.—The female worms discharge the eggs into the lumen of the intestine. The eggs reach the outside with the droppings. On bare soil and on pastures the eggs develop rapidly under favorable conditions, and hatch in a day or so. The newly hatched larvae find an abundance of food in their surroundings and undergo two molts in a week or less, under favorable conditions. The larvae retain the skin of the second molt as a loose sheath around the body; at this stage of development the larvae are capable of infecting susceptible pigs which might happen to swallow them

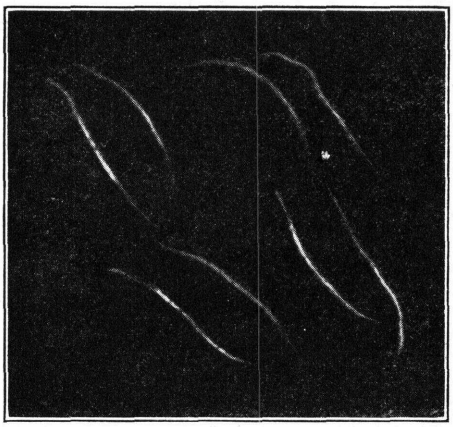

FIGURE 23.—Swine nodular worms (natural size).

with contaminated feed or water. Upon being swallowed by pigs, the larvae at first seek shelter in the wall of the large intestine, which they penetrate. As a result of the invasion by the larvae, the wall of the intestine becomes peppered with nodules (small elevations) each of which contains a young developing worm. Sooner or later the worms reach the stage of development at which they are ready to reenter the lumen of the intestine. This transfer is effected by a migration of the worms, the small opening at the summit of the nodule affording an exit for the parasites. The worms in the lumen of the intestine attain their full growth and sexual maturity about 2 months from the time the larvae were taken into the body.

Damage produced.—Nodular worm infestation is a contributing cause of unthriftiness in pigs, characterized by more or less weakness, constipation or diarrhea, anemia, and similar symptoms characteristic of parasitism in swine. Swine infested with nodular worms are usually infested also with other parasites, and it is difficult, therefore, if not impossible to assign a specific clinical signifi-

cance to nodular worms alone. As already stated, the penetration of the larvae into the intestinal wall produces nodules, those resulting from infestation with the common nodular worm being hardly larger than pinheads, as a rule, while those produced by the long-tailed variety are much larger, conspicuously raised above the sur-

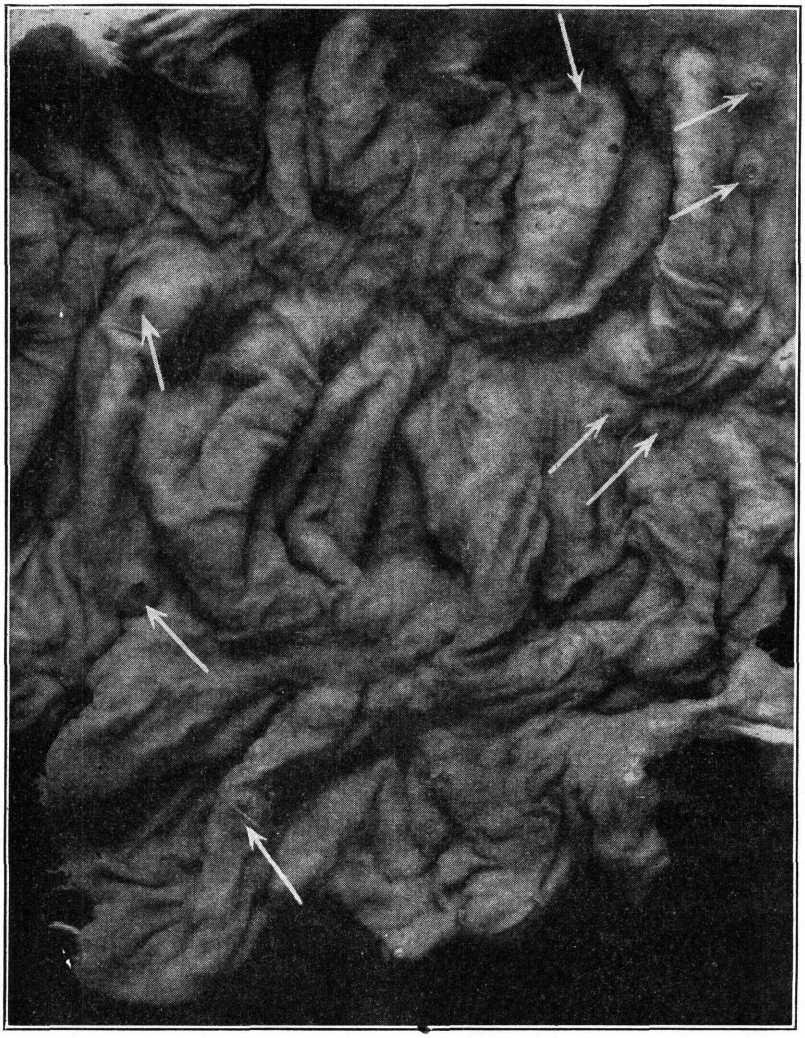

FIGURE 24.—Inner surface of large intestine of pig showing large nodules. Several nodular worms are shown on the surface of the intestine. (The bottom arrow indicates a nodular worm lying across the nodule.) (Natural size.)

face of the inner lining of the wall of the intestine, frequently highly inflamed, and sometimes complicated by secondary bacterial infection (fig. 24). Highly inflamed ulcerated nodules sometimes result from nodular worm lesions, and this in turn must contribute in no small measure to unthriftiness of the pigs. An ulcer is an open sore containing more or less dead tissue, bacteria and pus.

Aside from possible absorption of toxic material from ulcerated nodules, the danger of bacterial infection spreading from the nodule, with possible serious consequences, adds a further complication to this parasitic invasion.

Treatment.—Until the discovery of phenothiazine as an anthelmintic, there was no fully effective method for removing nodular worms from swine. When given to swine in adequate dosages, one treatment with phenothiazine will remove more than 90 percent of all nodular worms present in the treated animals. Methods of administering the drug and indicated dosages are discussed on page 23.

Control.—The swine sanitation system, together with the modifications designed for kidney-worm control, should be followed. The **A**-type farrowing houses should be moved to a new location at frequent intervals, at least once a week during warm weather, so that the larvae on the soil shaded by the houses may be killed

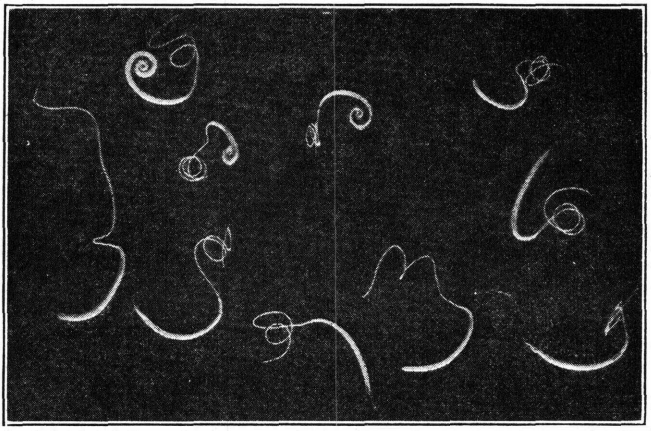

FIGURE 25.—Swine whipworms removed from the intestine to show their size and appearance (natural size).

by sunlight and drying. Only movable sun shelters should be used; otherwise nodular worm larvae will accumulate in places shaded by the shelters. The farrowing houses can serve as sun shelters if a door is provided at the back of each house; opening this door insures a free circulation of air. Good feeding is an aid in the control of these and other parasites of pigs. Well-fed pigs not only have a better resistance to the effects of parasites of all kinds, but also do less searching and rooting for feed in trash and litter; foraging and rooting, habits so pronounced in poorly fed hogs, result, as a rule, in heavy parasitic infestation.

THE WHIPWORM

Whipworms of swine, *Trichuris suis*, are from about 1⅓ to 2 inches long, the body consisting of a slender part followed by a relatively thick part. The slender portion of the worm bearing the head at the tip is about twice as long as the thick portion (fig. 25). The worms are located in the cecum and colon, the

minute head of the worm being rather deeply embedded in the lining of the large intestine (fig. 26).

Life history.—The adult worms in the large intestine of swine produce microscopic lemon-shaped eggs that are passed with the droppings. Once the eggs are outside of the body they develop to the infective stage, development being rather slow and requiring a month or longer under favorable conditions. High summer temperatures speed up the development of the eggs and low temperatures retard their development for several months. Pigs become infested as a result of swallowing the infective eggs with feed or water or while rooting in soil contaminated with the eggs. So far as is

FIGURE 26.—Inner surface of hog's cecum showing an infestation with whipworms (natural size).

known, the newly hatched larvae settle down in the large intestine and develop there to maturity in 4 to 5 weeks.

Damage produced.—If pigs harbor a few or a moderate number of whipworms, they show no noticeable symptoms. Massive infestations may cause unthriftiness, weakness, and emaciation; they may even kill a young pig. The attachment of the worms to the wall of the intestine produces an inflammation of the delicate lining.

Treatment.—No effective treatment for the removal of whipworms from swine has been established.

Prevention.—The methods recommended for the control of the large intestinal roundworm are also effective in controlling whipworms. The similarity in control measures for the two species of parasites is based on general similarity in life history.

THE SWINE KIDNEY WORM

The full-grown parasite, *Stephanurus dentatus*, is a thick, black-and-white, mottled worm about 1 to 2 inches long and about one-twentieth to one-tenth of an inch wide (fig. 27). The mature worms occur in cysts in the walls of the ureters (slender tubes that connect the kidneys with the bladder) and sometimes in the kidney tissue proper. The incompletely developed worms occur principally in the liver, in various blood vessels, especially those of the liver, free in the abdominal cavity, in fat surrounding the kidneys, embedded in the loin muscles, and in the lungs. Occasionally kidney worms penetrate the spine.

Life history.—The female worms produce large numbers of microscopic eggs (fig. 28). The eggs reach the cavity of the ureters through perforations made by the parasites in the walls of these tubes. From the ureters the eggs get to the bladder and are discharged to the outside with the urine. Under favorable conditions of tempera-

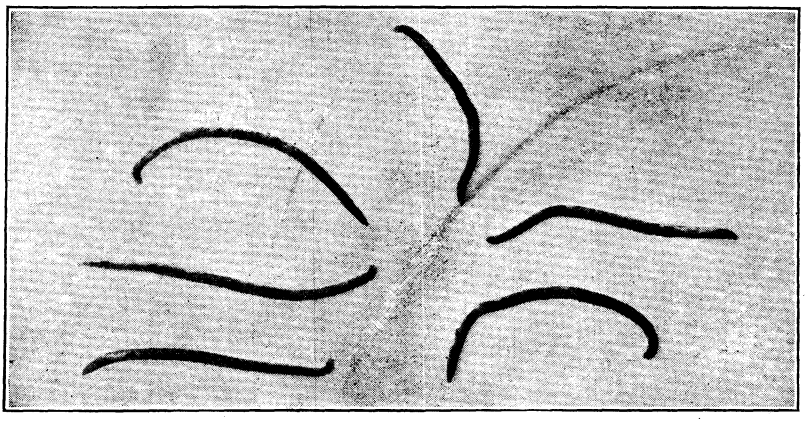

FIGURE 27.—Swine kidney worms (natural size).

ture, shade, and in the presence of an adequate supply of moisture, the eggs on bare soil or on pastures hatch in a day or two, and the larvae find abundant nourishment in their surroundings to permit growth and development. The larvae cannot ordinarily be seen with the naked eye. After casting off the skin once and subsequently reaching a state in which the second larval skin has become loose around the body, the larvae are in the infective stage. Under favorable summer temperatures, this stage is reached 4 or 5 days after hatching. In the cool weather prevailing early in the spring or late in the fall the development of the eggs and larvae may be delayed for a week or longer.

The eggs and the larvae offer comparatively little resistance to sunlight, drying, freezing, and other unfavorable influences to which they might be subjected in the open. However, the infective larvae can survive for several weeks in situations which afford moisture and shade. On pastures and lots which contain abundant shade and some moisture and on lots on which litter of all kinds,

including corncobs, corn husks, pine needles, leaves, etc., is allowed to accumulate, the larvae find ideal conditions for survival (fig. 29). Pigs kept on such contaminated areas have abundant opportunities of swallowing the larvae with contaminated forage, or other feed, or while rooting. Aside from becoming infested as a result of swallowing the larvae, pigs can acquire an infestation with kidney worms as a result of lying down on contaminated pastures and lots. The heat of the pig's body stimulates the larvae and as a result of this stimulation, the worms become active and penetrate the

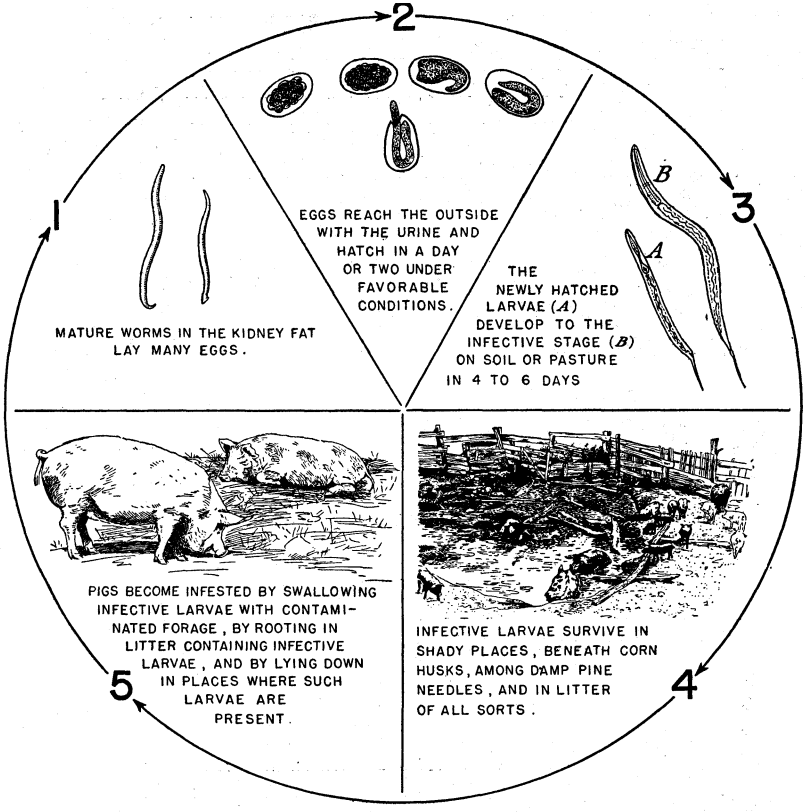

FIGURE 28.—Life history of swine kidney worm.

pig's skin. However, regardless of the path of entry into the bodies of pigs, the larvae get into the blood stream and are carried to the liver, lungs, and other internal organs. In the liver, the young worms ultimately bore through the walls of the finer blood vessels, wander in the liver tissue proper, and finally perforate its outer covering, known as the capsule. This brings the worms to the surface of the liver, over which they move freely. The worms continue their migrations in the abdominal cavity, coming in contact with the various abdominal organs. On reaching the kidney fat in the course of their migrations in the abdominal cavity, the worms

have little difficulty in pushing into this relatively soft tissue. Other wandering worms get into the loin muscles and into other organs and tissues. Only those worms which reach the kidney fat succeed in migrating to the kidneys and ureters, the walls of which they

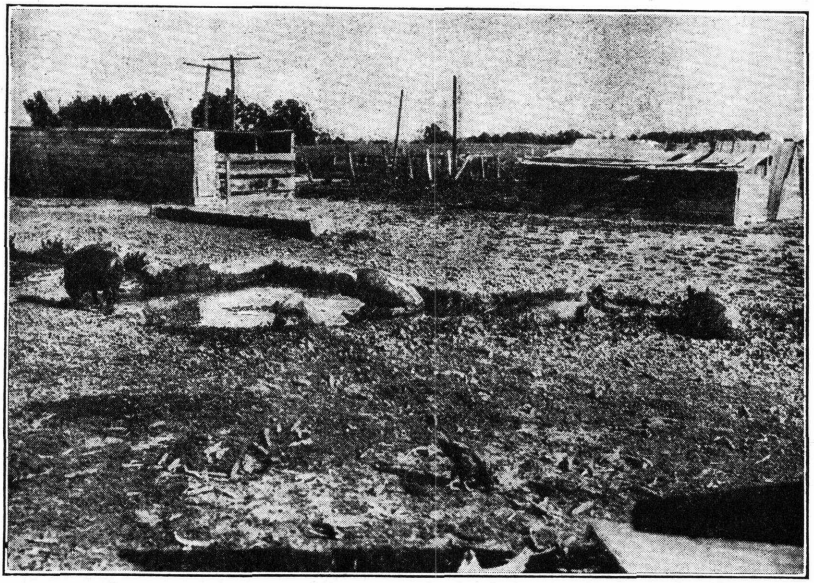

FIGURE 29.—Hog lot in which kidney-worm larvae as well as eggs and larvae of other swine parasites are likely to be abundant.

FIGURE 30.—Portion of spine of a hog split open to show kidney worms in spinal canal. Arrows point to the worms (seen as long dark bodies).

penetrate. Location in these places affords an outlet for the eggs, which, as already stated, are expelled with the urine.

The cycle of development of the kidney worm within the body of a pig up to the time that the eggs are ready to be discharged with the urine is a slow one, requiring 6 months or longer, as a rule. Sooner or later the worms disintegrate, and a whitish mass consisting of pus is usually found in association with the dead parasites.

Damage produced.—Aside from general unthriftiness and arrested development, symptoms common to parasitic infestations of all kinds, there are no readily observable symptoms that are especially characteristic of kidney-worm infestation. Infested animals discharge urine which at times contains pus, this being characteristic of kidney-worm infestation. Posterior paralysis is sometimes due to the penetration of kidney worms into the spine (fig. 30). Most cases of paralysis of the hind quarters are due, however, to other causes.

It is evident that parasites as widely distributed throughout the bodies of swine as are kidney worms will produce more or less serious damage in the tissues and organs in which they lodge or with which they come in contact. The principal injury inflicted by

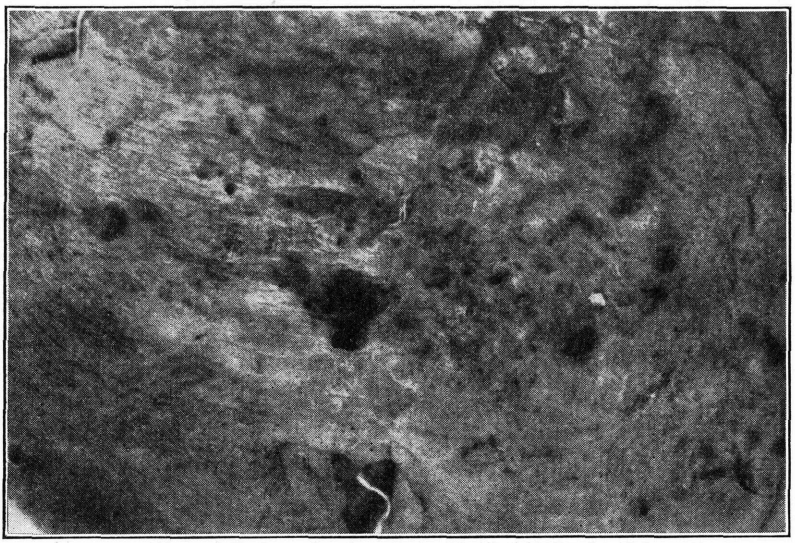

FIGURE 31.—Swine liver with numerous bloody tracks produced by kidney-worm migration.

kidney worms involves the liver. The worms that migrate through the liver and perforate its capsule produce bloody tracks (fig. 31). As these active lesions heal, the damaged liver cells are replaced by hard connective tissue which produces the grayish-white liver scars characteristic of kidney worm infestation (fig. 32). These hard areas may be small, circumscribed, and more or less superficial or large and striking and extending deeply into the liver tissue. Pus is commonly associated with the worms which lodge in the liver lesions. Under meat-inspection procedure considerable losses are sustained owing to the rejection and condemnation of affected livers. The invasion of the loin muscles (fig. 33) necessitates considerable trimming of expensive parts of hog carcasses. When the infestation is excessive and is accompanied by pus, considerable portions of a carcass and sometimes an entire carcass must be condemned. These losses are ultimately borne by swine producers, who receive a

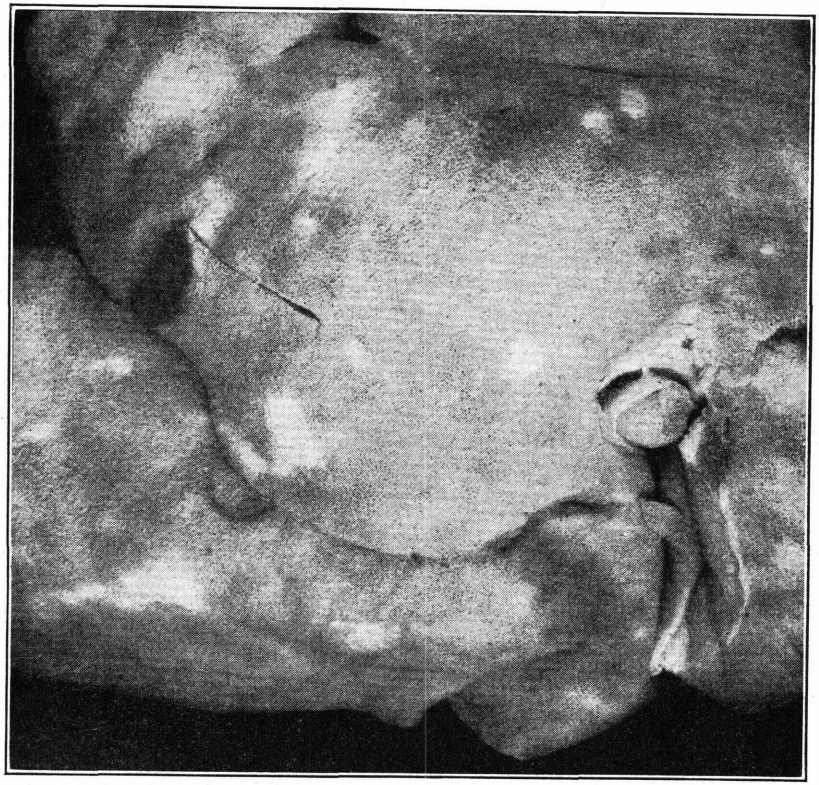

FIGURE 32.—Swine liver showing numerous scars (whitish areas) produced by kidney worms.

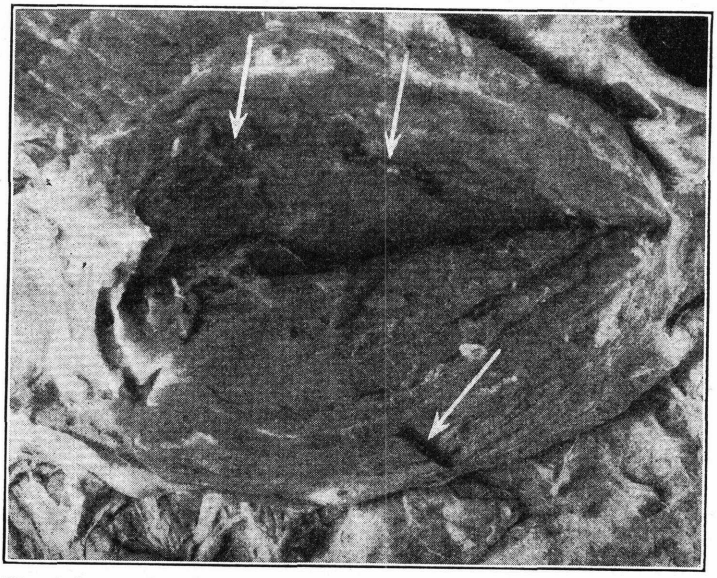

FIGURE 33.—Loin muscles of a hog cut open to show kidney-worm invasion. Arrows point to kidney worms (natural size).

lower price for hogs because of expected injuries as well as because of the injuries to hog carcasses actually produced by the parasites.

Other important injuries produced by kidney worms involve the lungs, which contain hard nodular masses marking the locations of the worms and associated pus; the blood vessels, in which incompletely grown worms become arrested and in which they produce changes that interfere with the circulation of the blood; the ureters, the walls of which become thickened when the worms lodge in them; the kidney fat, which is unfit for rendering into lard because of infestation with worms; and the spleen and other organs which are sometimes invaded by the parasites.

Treatment.—There is no known medicinal treatment for the removal of kidney worms from the blood vessels, liver, kidney fat, kidney proper, lungs, loin muscles, or the other locations in which these parasites occur.

Prevention.—The control of kidney-worm infestation must be based on preventive measures. Prevention in this case means reducing pasture contamination by observing certain fundamental precautions as regards sanitation. This, in turn, involves arrangements which will expose kidney-worm eggs and larvae to the sun, prevent the accumulation of litter and trash on hog pastures, and provide good drainage. This program can be carried out as follows:

The pasture on which the pregnant sow is placed shortly before farrowing should be a well-drained, temporary pasture that has been especially prepared by being sown to a suitable forage crop. There should be a bare area preferably all around the pasture (fig. 34) but at least at one end of it. The bare area at the end should be sufficiently wide (about 30 feet) to accommodate the shelter houses, watering barrel or other supply, creep with self-feeder for the pigs, and a feeding pen for the sow. The remaining bare area should be provided, if possible, but it need not exceed from 3 to 5 feet in width. The entire bare area should be free from trash and litter. Under this arrangement a considerable portion of the sows' urine will be deposited on the bare soil in the wide, bare area and along the fences. Under this arrangement kidney-worm eggs eliminated with the urine of infested sows will be deposited, for the most part, where they will perish from exposure to sunlight, heat, and drying. In the absence of vegetation, the top-soil is sufficiently dry, except during wet seasons, to destroy life in the eggs and larvae of these worms.

By providing a separate feeding pen for the sows and, at some distance away, a creep with self-feeder for the pigs, a considerable portion of infective material will be kept away from the pigs. To accomplish this result, the gate of the sows' feeding pen should be kept closed to keep the pigs out; the gate should be opened only to admit the sows to the feeding pen and to drive them out about an hour after feeding. Sows tend to urinate after feeding, and the kidney-worm eggs deposited with the urine will remain and ultimately perish in an area where the larvae which issue from the eggs will not reach the pigs, provided the drainage from the sows' feeding pen does not reach the pasture.

This entire arrangement, designed to provide effective, natural barriers to the development of kidney-worm eggs and larvae, is an

effective and practical method of combating one of the most serious parasites which infests swine. Although the sows will also urinate on the pasture and thus deposit eggs there, the plan previously outlined has the advantage of eliminating a major part of the infective material, thus reducing the degree of infestation to a point where it will do little harm.

The pigs should be weaned as early as is consistent with sound husbandry practices and the weaned pigs moved to a clean pasture, preferably one that has not been occupied by pigs for 6 months or longer. The best procedure is to move the pigs to a temporary pasture that has been sown to a forage crop since its previous occupancy by pigs. This precaution will preclude infestation with

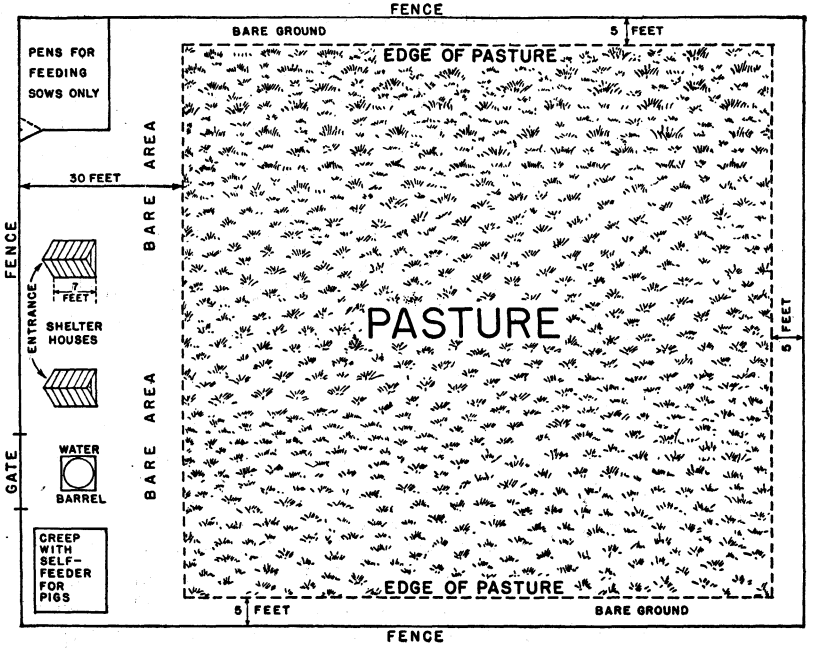

FIGURE 34.—Diagram showing the kidney-worm control plan.

kidney worms following weaning, provided the pasture is so located that it will receive no drainage from areas occupied by the older breeding stock.

In short, the precautions to be followed are intended to protect the pigs from acquiring a marked infestation while they are with the sow, and to avoid any kind of infestation after weaning.[3]

LUNGWORMS

Three species of lungworms, *Metastrongylus elongatus*, *M. salmi*, and *Choerostrongylus pudendotectus*, occur in swine, the first- and third-named species occurring in relatively large numbers, as a rule, whereas the species listed second usually occurs in small numbers,

[3] Additional information on controlling kidney worms is given in U. S. Department of Agriculture Leaflet No. 108, Controlling Kidney Worms in Swine in the Southern States.

when present. Swine are usually infested by two or all three species, all of which are relatively long, slender, whitish worms, from about one-half to 2 inches long by about one-fiftieth of an inch or less wide (fig. 35). These parasites are found occasionally in the windpipe, more often in its two main branches called the bronchi, their pre-

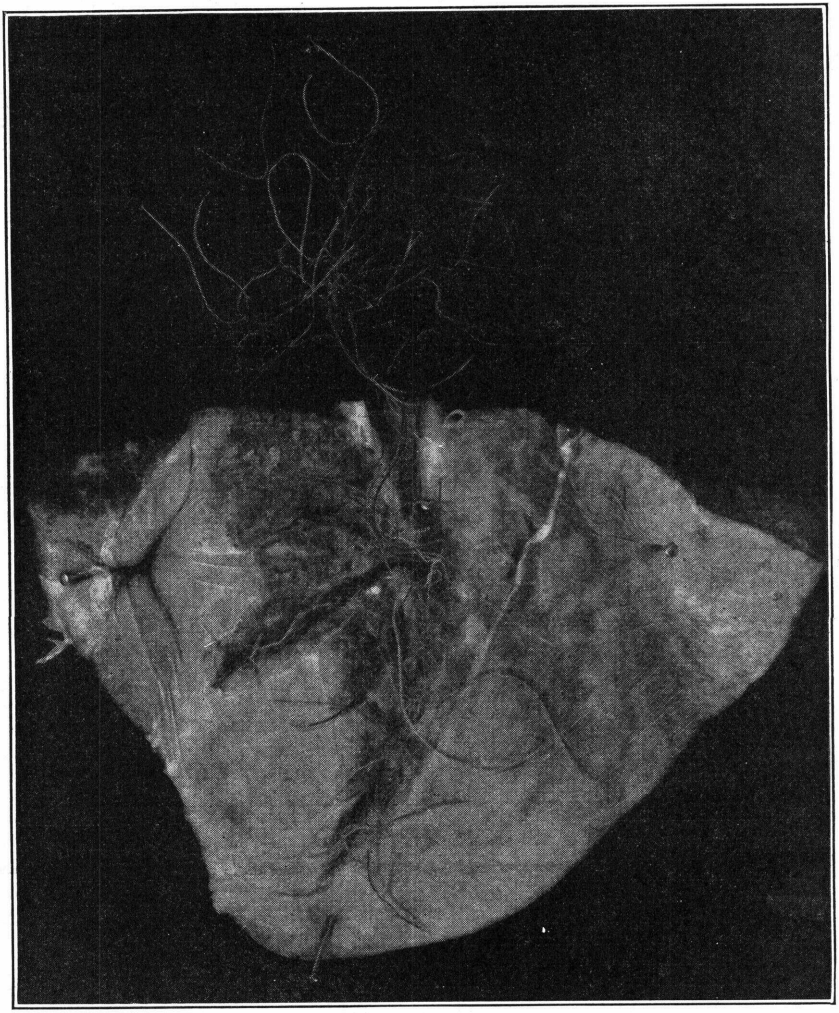

FIGURE 35.—Lower portion of swine lung partially cut open to show the nests of lungworms. Several lungworms were removed to show their size and shape.

ferred location, however, being the smaller bronchi and the bronchioles (the finer branches of the bronchi), and especially those in the lower portions of the lungs. So far as is known, the three species of lungworms which parasitize swine are equally injurious, the degree of injury produced depending upon the number of worms present in individual pigs.

Life history.—Figure 36 shows the complete life cycle of the lungworm. The female worms in the lungs of infested pigs produce large numbers of eggs, which are coughed up, swallowed, and eliminated with the droppings. At that time each egg contains a young worm. Earthworms, or angleworms, feeding on swine manure or on soil contaminated with swine manure, swallow the eggs. The latter hatch and develop in the body of earthworms to a stage in which they are infective to swine. Pigs acquire a lungworm infestation as a result of swallowing infested earthworms which they bring to the

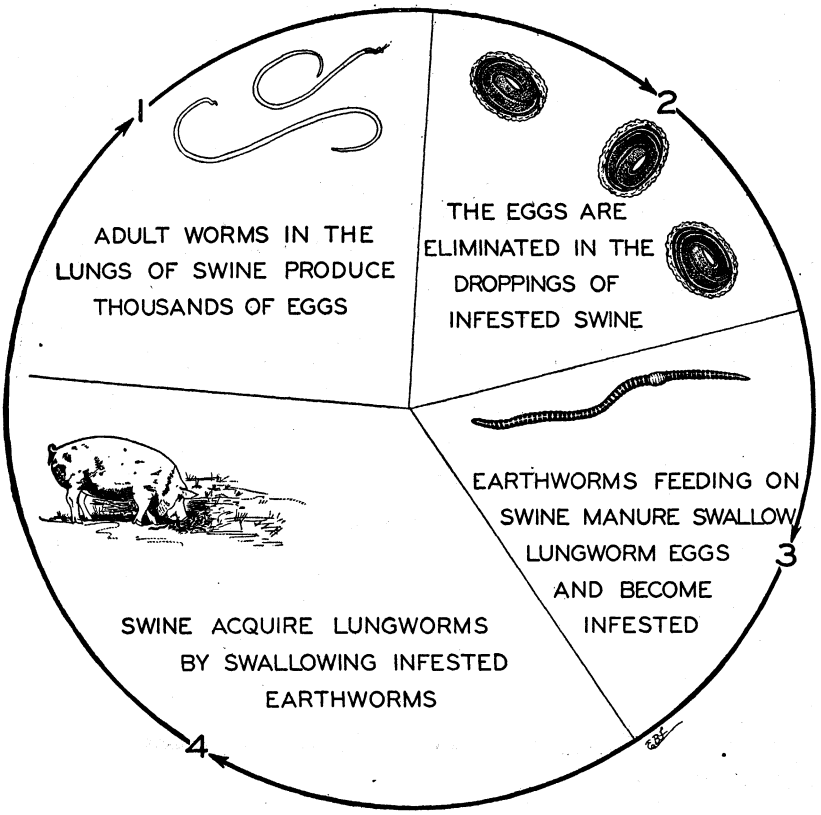

FIGURE 36.—Life cycle of swine lungworms.

surface by rooting. A single earthworm may harbor from several to about 2,000 or more lungworm larvae; the latter number is sufficient to produce a heavy infestation in a pig which might happen to swallow such a heavily infested worm. The lungworm larvae contained in infested earthworms become free in the alimentary canal of pigs as a result of the process of digestion. Once they are free in the intestine, the young lungworms penetrate its wall, and follow the course of the lymph which leads to the heart, and thence to the lungs. Lymph is a body fluid similar to blood, but it lacks the elements which give blood its red color. In about 4 weeks after a

pig has swallowed infested earthworms, the lungworms have developed to the egg-producing stage, and the droppings of such a pig are capable of infecting a fresh crop of earthworms.

Damage produced.—Symptoms of severe lungworm infestation in young pigs include coughing, difficulty of breathing, loss of appetite, weakness, and failure to grow. These conditions may cause death. In older hogs, coughing and shortness of breath are outstanding symptoms. In heavy infestations the finer bronchi and bronchioles are plugged with worms, and this produces a localized pneumonia. During the early stages of invasion by these worms, the lungs are peppered with hemorrhages resulting from the perforation of the walls of the delicate blood vessels in the lungs (fig. 37). In infestations of long

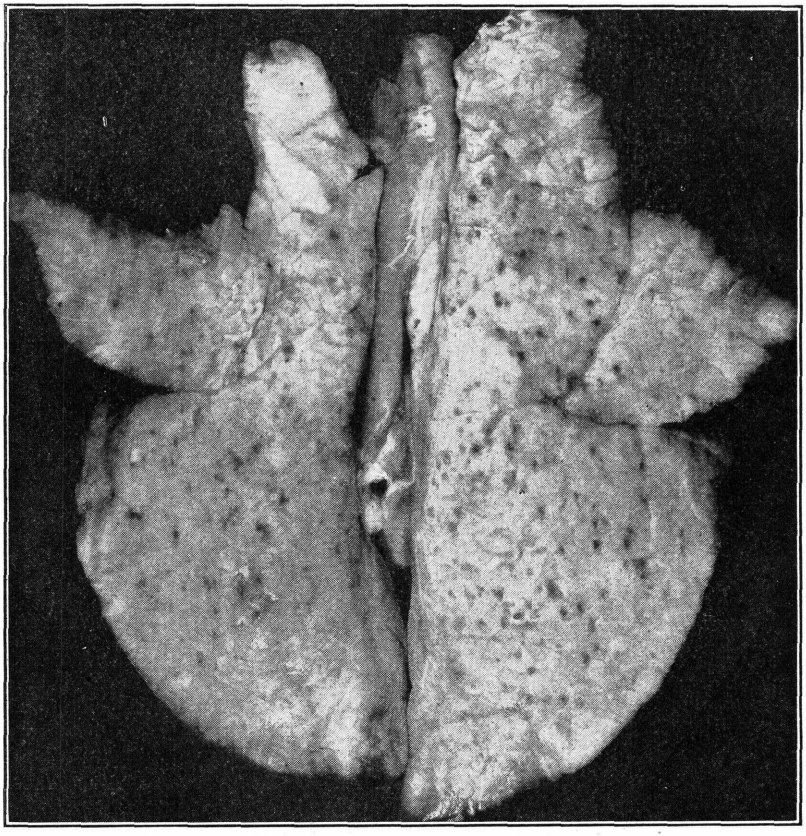

FIGURE 37.—Lungs of a pig 4 days after infection with lungworms. The dark spots over the surface of the lungs are small hemorrhages.

standing, the posterior tips of the lungs commonly show grayish, hardened areas marking the location of worms in the bronchi and bronchioles.

Treatment.—There is no known medicinal treatment effective in removing these worms from the lungs. Infested animals should be taken off the pasture or out of the lot and placed in a dry, clean pen,

preferably one with a concrete floor, to insure against further infestation from swallowing infested earthworms. While kept in isolation, sick pigs should be supplied with milk and other nutritious appetizing food, safe drinking water, and good bedding that is renewed at fairly frequent intervals.

Prevention.—The control of lungworm infestation in pigs involves arrangements which will reduce the number of earthworms on pastures and lots and prevent swine from rooting. Earthworms thrive in old hog lots in which manure and litter accumulate, old straw stacks, on permanent pastures, and in low fields which receive drainage from higher fields. Well-drained fields, on which crops are cultivated seasonally, contain comparatively few earthworms.

Effective control of lungworm infestation involves the use of the sanitation system of swine management, the absolute avoidance of old hog lots, and the selection of well-drained pastures, fencing off, if necessary, the lowest portions of pastures to which rain and wind carry manure and other litter. As an additional precaution, it is important to ring the noses of swine to prevent excessive rooting.[4]

TRICHINA

Trichinae, *Trichinella spiralis*, are slender threadworms, occurring in the small intestine of swine as adults, in the blood as migrating larvae, and in the muscles as encysted or encapsulated worms. The adult worms in the small intestines are from one-sixteenth to one-sixth inch long and about as wide as a very fine thread; the migrating worms in the blood are microscopic in size; the encapsulated larvae in the muscles are spirally rolled, are about one twenty-fifth of an inch long, but are not ordinarily visible to the naked eye. Trichinae occur not only in swine, but also in human beings, rats, mice, dogs, cats, and in various other meat-eating animals.

Life history.—Figure 38 illustrates the complete life cycle of trichinae. The adult worms in the intestines are rather short-lived, but, before they die and pass out with the droppings, the females produce numerous young worms which are deposited directly in the lymph spaces in the wall of the intestines. From the lymph channels the worms reach the large blood vessels leading to the heart, the heart itself, and the blood vessels leaving the heart, and are carried by the blood to all parts of the body. When the young worms in the blood stream reach the muscles, they penetrate the muscle fibers and grow at the expense of the muscle tissue. In about 3 weeks after they get into the muscles the young worms have attained their maximum size, become spirally coiled, and a thin membrane or cyst about one-fiftieth of an inch in diameter forms around each worm. Occasionally two or more worms are enclosed in a single cyst or capsule. The encapsulated worm is trapped in the muscles and can undergo no further development until the muscle tissue in which it is lodged is eaten by another susceptible animal. Pigs acquire trichinae as a result of eating scraps of pork containing the encysted worms, or as a result of eating dead pigs, dogs, cats, rats, or mice harboring encysted trichinae. Rats and mice become infested as a result of eating scraps of infested pork or infested rats and mice. Dogs and cats

[4] Additional information on lungworms is given in U. S. Department of Agriculture Leaflet No. 118, Controlling Lungworms of Swine.

become infested as a result of eating infested raw pork or infested rats or mice. Human beings become infested with trichinae, usually as a result of eating raw or imperfectly cooked pork infested with these parasites.

When a hog or any other susceptible animal swallows flesh containing encysted trichinae, the flesh and the cysts are digested in the stomach, thus liberating the young parasites which then pass into the intestines; in about a week or so they begin producing the new

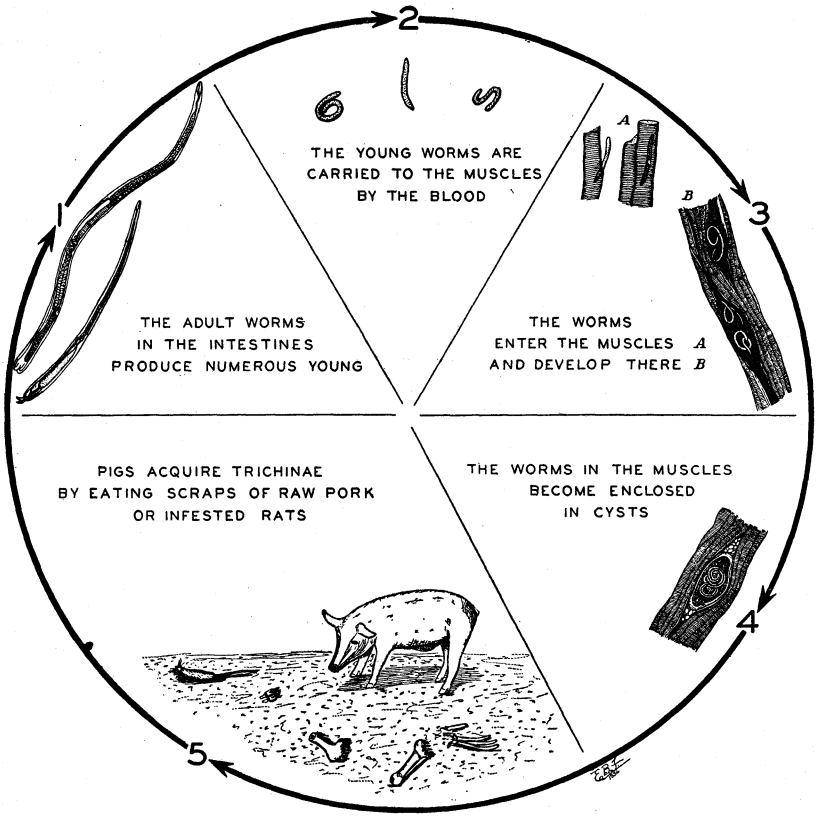

FIGURE 38.—Life cycle of trichinae. The worms shown are highly magnified.

generation of young worms, which migrate to the muscles and ultimately become encysted there.

Damage produced.—The disease produced by trichinae is known as trichinosis. Trichinosis is practically never diagnosed in swine during life because other and better-known diseases of these farm animals show symptoms similar to those of trichinosis. Consequently, trichinosis in swine is probably confused with other diseases. Within a few days after a large quantity of trichinous meat has been eaten, affected hogs take no food, vomit at times, crouch in the straw, and move about with difficulty. When the young worms invade the muscles, beginning about the second week after infestation, affected hogs move about stiffly and frequently lie motionless in one place.

There may be considerable swelling, especially of the eyelids. Recovery is the rule, unless the infestation is very severe. With the encystment of the worms in the muscles, the symptoms gradually disappear, the affected animals regain their appetite and apparently make a good recovery. Due to the invasion of the muscles by the parasites, important changes take place in them, but with recovery the muscles take on a normal appearance. However, the encysted worms may remain alive in the muscles for a year or longer. The symptoms mentioned are observed in rather severe experimental infections. In light infections all or nearly all of these symptoms may be lacking.

Treatment.—There is no known effective treatment for trichinosis in swine or in any other animal.

Control.—The control of trichinosis in swine involves management tending to eliminate the sources of infestation. Since swine acquire trichinae by swallowing trichinous pork or by devouring the flesh of infested rats, mice, or other animals, it is important to eliminate these sources of infestation. There is danger that hogs will become trichinous if they receive garbage containing uncooked pork or offal from slaughterhouses. The incidence of trichinae in garbage-fed hogs is about five times that in grain-fed hogs. The feeding of uncooked garbage to hogs should be avoided therefore, as a control measure for trichinosis in swine. Hogs which die on the farm should not be left on the pasture or lot to be eaten by other hogs; the carcasses of such hogs should be buried deeply in quicklime, or preferably the carcasses should be burned. The swine sanitation system described on pages 23–26 will aid materially in controlling trichinosis in hogs and thus reduce the chances of spreading a disease which is dangerous not only to the health of swine but which also affects human beings, producing a serious, and very painful disease.[5]

SUMMARY OF CONTROL MEASURES

The principal known methods of controlling internal swine parasites are briefly as follows:

Bladder-worm infestation may be prevented by the use of modern sanitary sewage disposal or sanitary privies on farms and in rural communities and by restricting the wanderings of dogs so as to keep these animals off hog pastures. Periodic treatment of dogs for the removal of tapeworms is an additional precaution.

Sanitation, involving the use of temporary pastures sown to suitable forage crops, selecting pastures that are well-drained, and keeping them free from trash and litter are fundamental methods of controlling Protozoa, stomach worms, intestinal roundworms, threadworms, whipworms, thorn-headed worms, nodular worms, kidney worms, lungworms, and trichinae.

The use of pastures with bare areas, as recommended in this bulletin, is an additional precaution and affords an effective and practical method of controlling kidney worms. This method should be followed on hog pastures in the South.

If temporary pastures cannot be made available, permanent pastures from which hogs have been excluded for at least a year

[5] Additional information on trichinosis is given in U. S. Department of Agriculture Leaflet No. 34, Trichinosis: A Disease Caused by Eating Raw Pork.

may be substituted. Suckling pigs should be protected from association with older hogs other than their mothers. After weaning and until they are ready for market, the pigs should still be protected from association with other hogs, and especially with the older breeding stock.

The pastures should have good fences to keep the pigs from getting into low, wet areas. Such areas are dangerous because they harbor earthworms, grubs, and adult insects which convey, respectively, lungworms, thorn-headed worms, and stomach worms to swine. Wet areas in certain regions may harbor snails that convey liver flukes and crayfishes that convey lung flukes to swine.

Clean, well-fenced temporary pastures sown to suitable forage crops tend to reduce parasitic infestation to a low level. Adequate supplemental feeding helps to minimize the effects of parasitism, and by reducing the tendency of pigs to search for food by rooting protects them to a considerable degree from lungworms and thorn-headed worms. These worms spend part of their life cycles in earthworms and white grubs, respectively. Ringing the noses of pigs is a well-known method of preventing rooting.

Skim milk or whey can be used to protect pigs against the acquisition of nodular worms, whipworms, and to a lesser extent, large roundworms. The skim milk or whey should be fed daily in lieu of one grain feeding, or for 3 days in succession in lieu of all other feed, at intervals of 2 weeks. When skim milk or whey is fed to prevent acquisition of worms as much should be given as the pigs will drink. When either regime is followed the parasites named are either not acquired, or are acquired in such small numbers as to produce practically no injury to the host animal. Pigs so fed make satisfactory weight gains and remain in good condition.

The avoidance of uncooked pork in hog feed, the proper disposal of offal from hogs slaughtered on the farm and in country slaughterhouses, keeping rats and mice out of hog lots, and the burning or deep burial of dead hogs will tend to reduce trichinosis in hogs. A rigid adherence to the swine sanitation system will control trichinosis effectively.

As a number of the parasites discussed in this bulletin are transmissible to human beings, a strict adherence to the sanitation system of management is important not only in the interest of proper swine husbandry but also for safeguarding human health.

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